"Injuries to the Soft Tissues of the Extremities," written by Harrison L. McLaughlin, M.D., F.A.C.S., New York;

"Treatment of Burns," written by Harvey S. Allen, M.D., F.A.C.S , Chicago.

The Harvey Cushing Society for—"Management of Acute Head Injuries," written by a committee composed of Frank H. Mayfield, M.D., F.A.C.S., Cincinnati, chairman, Spencer Braden, M.D., F.A.C.S., Cleveland, Dean H. Echols, M.D., F.A.C.S., New Orleans, and the late Cobb Pilcher, M.D., F.A.C.S., Nashville.

"Management of Acute Peripheral Nerve Injuries" written by a committee composed of Barnes Woodhall, M.D., F.A.C.S, Durham, chairman, Loyal Davis, M.D., F.A.C.S., Chicago, and Henry G. Schwartz, M.D., F.A.C.S., St. Louis.

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The American Board of Plastic Surgery for the chapter on "Principles of Treatment in Severe Facial Injuries" written by Bradford Cannon, M.D., F.A.C.S., Boston.

The American College of Surgeons' Advisory Committee on Ophthalmology for "Initial Treatment of Acute Injuries to the Eye." At the time this chapter was developed, this group was composed of Derrick T. Vail, M.D., F.A.C S., Chicago, chairman, Edwin B. Dunphy, M.D., F A.C.S., Boston, S. Rodman Irvine, M.D., F.A.C.S., Beverly Hills, Lawrence T. Post, M.D., F.A.C S., St. Louis, and William B. Clark, M D., F.A.C.S., New Orleans. Dr. Clark was the editor.

The American Association for Thoracic Surgery for the chapter "Initial Management of Patients with Thoracic Injuries," written by a committee composed of James H Forsee, Colonel, M.C., U.S.A., F.A.C.S , Denver, chairman; I. A. Bigger, M.D., F.A.C.S., Richmond, Thomas H. Burford, M D., F.A.C.S., St. Louis, Dwight E. Harken, M.D , F A C S , Boston, and Paul C. Samson, M.D , F.A.C.S., Oakland

The American Surgical Association for the chapter on "Early Care of Injuries to the Abdomen," written by a committee composed of William F. MacFee, M.D., F.A.C.S., New York, Ambrose H. Storck, M.D., F.A C S., New Orleans, John D. Stewart, M.D., F.A.C.S , Buffalo, Charles B. Puestow, M.D., F.A.C.S., Chicago,

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otherwise, is given by anyone on the spot and the only agency making a serious attempt to train the general public in proper first-aid measures is the American Red Cross. This organization reaches a great many people and its efforts in this line deserve the co-operative support of the medical profession. It is very easy to criticize first-aid measures and to point out better methods, but one must be in the position of having to give first aid under the conditions existing at the site of an accident to appreciate the problem truly.

The chapter on examination of the patient should be thoroughly digested. With a complete diagnosis, and an accurate evaluation of the general condition of the patient, the battle is half won. Many errors in care are due to incomplete diagnoses, to overlooking some serious injury while concentrating on the obvious. A systematic method of examination will obviate such errors.

Emphasis on the general principles of care of open injuries will be found to run through all the chapters. However, a brief summary of them seems to be appropriate at the beginning of this manual.

The remainder of the manual deals with specific anatomic areas or specific topics. Each chapter is complete in itself, but should be related to others by the reader

It is hoped that the manual will prove valuable to all physicians who have to do with the treatment of injuries. It does not pretend to be a complete treatise nor does it cover the often complicated and specialized aftercare which some injuries require. It is felt, however, that it will serve as a useful guide to the immediate treatment of wounds and will make possible proper carrying out of the initial surgery of the injury on which all else depends

MICHAEL L. MASON, *Chairman*
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derly or shifted and moved about in bed by well-meaning persons. Any one of these changes in position may lead to serious damage—a fractured spine may sever the cord, a clot may be loosened in a large vessel and lead to hemorrhage, a closed fracture may perforate, a dressing over an open chest wound may shift and a serious respiratory complication occur suddenly.

It is the surgeon's duty to supervise the handling and manipulation of the injured patient at all times, to make certain that no further injury is caused by the various phases of examination, undressing, changes in position, et cetera. He cannot simply order x-rays of this and that part and wait for results. He must be certain that, if x-rays are needed, the necessary manipulations do not cause harm.

V. CARE OF THE OPEN WOUND ITSELF.

A. *Provide for suitable anesthesia.*

B. *Cleanse the area surrounding the wound and then cleanse the wound itself.* This important phase of care must be done under aseptic precautions with gowns, gloves, and masks. It is not a perfunctory swishing with soap and water but a careful cleansing. The surrounding area is first cleansed, the wound itself being covered with a sterile dressing. The dressing is then removed and, with a fresh set-up, the wound itself is washed and irrigated.

Practices vary somewhat in the selection and use of the cleansing agent. Many surgeons use plain soap and water both for cleansing the skin and for cleansing the wound. Others use soap and water for the skin and simply irrigate the wound with large amounts of normal saline solution. Some surgeons prefer to use one of the mild detergents. One important thing is that the cleansing should be carried out with as careful a technique as the surgeon follows in washing his own hands for operation.

C. *Wound excision and removal of foreign bodies.* The purpose of excision is to remove all hopelessly devitalized tissue. The greatest source of postoperative wound disturbance is necrotic tissue left in the wound at the time of initial care. This is not a wound excision in the sense so often understood, i.e. excision of the whole lining of a wound. The concern of the surgeon here is to remove tissue destined to succumb because of the amount of injury it has sustained. Each tissue is taken in turn and a systematic excision carried out. To be avoided is needless sacrifice of viable tissue The skin especially must be carefully considered. In sharp cutting wounds little if any of the skin border need be excised. In severe crushes and avulsions large areas of skin may be nonviable and require excision. The object is to leave only viable tissue.

Foreign bodies are removed as encountered in the wound.

D. *Deep repair as commensurate with the type of injury.* Here the reader is referred to the various chapters dealing with specific injuries.

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FIRST AID AND EARLY CARE

"First aid is the immediate and temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained. It may mean the difference between life and death, between rapid recovery and long hospitalization, between temporary disability and permanent injury." A physician is present infrequently to render first aid, but he may be, and he needs to know the fundamentals as well as the trained layman. He should be competent to advise on the preparation of first-aid manuals or to instruct first-aid classes, if requested. Further, he must have enough knowledge not to criticize adequate first-aid if he has nothing better to offer There are many first-aid manuals of varying value, but the American Red Cross First-Aid Textbook is probably the most complete, safe and frequently revised. Interns, residents and the general profession should know its content.

Keep an open airway.

All wounds are contaminated. Prevent further contamination by covering with a sterile dressing. Don't use antiseptics. If a period of several hours must elapse before definitive treatment can be given, and soap and running water are available the wound may be washed with these before applying a sterile dressing, except in the case of burns.

External bleeding can almost always be stopped with a pressure dressing Pressure points are not worth considering. Never use a tourniquet unless absolutely necessary as there are undoubtedly more deaths and loss of limbs from the use of a tourniquet than from failing to use one. However, the physician should know how to apply one properly.

If the injured person is found unconscious and has alcohol on his breath, consider that he has a brain injury until proved otherwise. Keep him lying on his side so that his tongue does not fall back causing him to drown in his own secretions

Splint fractures.

Care that all moving is done without further damage to the patient, rather than speed of transportation, is the important criterion. Lives are lost by speed without care.

In this section we can only outline basic principles to prepare the injured person for definitive care in an operating room. This will not include the care of fractures, except as they occur in multiple injuries. The care of injuries of the bones is covered in *An Outline of the Treatment of Fractures.*

Let us assume that a seriously injured person or one with multiple injuries is presented to us. The care of asphyxia, shock and hemorrhage,

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tion, the blood vessels, the retroperitoneal organs and vessels, the spine and spinal cord, perforation of the diaphragm, etc. Is concealed hemorrhage taking place? We must decide as soon as possible whether any operative procedure is indicated, which part of the body will be approached first when the condition improves sufficiently to do anything, whether any improvement can be expected in the general condition until some intervention has been accomplished, even if the person may die during the attempt.

These decisions may need to be changed as the condition of the patient changes, but we must constantly keep in mind doing first things first. There is no use applying skeletal traction for a fractured femur and spending time carefully arranging traction suspension when we believe the abdomen must be explored at the earliest possible moment, requiring the taking down of the traction apparatus. Rather keep the part in emergency traction until decision is made regarding the abdominal trauma.

X-ray examination is often carried to a ridiculous extent. What films do you absolutely need to determine the optimum time to initiate definitive treatment and the interim care to prevent further injury? Demonstration of free air below the diaphragm may prove rupture of a hollow viscus. Examination for this is of little use unless the patient is in the upright position. The absence of a vertebral column injury may need to be proved before the patient can be supported in the sitting position without danger of spinal cord damage. However, the use of a tilt table allows the examination for free air without endangering the spinal cord.

Too many early x-rays of the skull are taken Unless the patient is cooperative enough to keep his head quiet these should be postponed, unless one believes it is absolutely necessary to determine the presence of an open depressed fracture or of a fracture at a site which could readily produce an injury to the middle meningeal artery. Otherwise no operative intervention on the skull is going to be instituted early and better x-rays for the record may be done later.

The x-ray proof of fractured ribs will usually make little difference in early operative treatment. There may have to be treatment for pain on breathing, for tamponade of the lungs with blood, for paradoxical respiration or tension pneumothorax, but time and effort spent on x-ray of the chest offer little in the early care of the extensively injured that cannot be learned equally well or better by the physical examination. Anesthetizing the proper intercostal nerves often changes the picture entirely in a patient suffering severe chest pain. The blood must be kept oxygenated; adhesive strapping to the chest interferes with this.

Beds in the admission ward are a practical necessity in these cases. Close supervision is necessary. Many patients suffer further injury and exposure during movement from stretcher to x-ray table, ward bed or

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PHYSICAL EXAMINATION OF THE INJURED

BECAUSE ITS FINDINGS determine diagnosis, prognosis, and treatment, physical examination is the first and perhaps the most important procedure in the management of any injury. Comprehensively reviewed, the examination is essentially a process of noting the features of the injury and the patient's reaction to it. To do this adequately the examiner must obtain the fullest information possible on the following points:

1. The character and extent of obvious injury,
2. The possibility of any coexistent concealed injuries,
3. The presence of any disability which may be affected by the injury, and
4. The general condition of the injured subject.

Theoretically, the examination of injury cases should be completed with the same careful regard for detail exercised in the examination of those with less urgent complaints. Practically, such detailed examination is seldom possible since the character of the injury, condition of the patient, and inadequacy of facilities frequently place restrictions on the examiner. Disregarding such restrictions in the overzealous attempt to perform complete physical examination upon severe injury cases is likely to result in additional harm and gain slight additional information. Thus the physical examination of injured subjects must in many instances be limited or considerably modified of necessity. But let it be emphatically pointed out that this in no way excuses the examiner from making the fullest examination allowed by the limitations of any individual case.

Certain general precepts obtain in the examination of all cases of trauma. Because they are likely to be unfamiliar to the novice, and frequently neglected by the experienced examiner, they are emphasized as follows:

1. An examination must be made however and wherever possible. The state of consciousness determines, to a very large extent, the amount of accurate information the injured subject can give concerning the circumstances of his injury and his symptoms. It must be remembered that the state of consciousness in traumatic cases may frequently change in very short periods. The examiner must therefore take advantage of any conscious interval, wherever or however it occurs, to gain as much information as possible. Regardless of how many examinations have been carried out with the injured subject in a comatose or wholly unconscious condition, additional examination must be made as soon as possible upon return to full or approximately full

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Bearing the above general considerations in mind, it is appropriate to emphasize certain specific features particularly important in the examination of traumatic cases. For comprehensive discussion these features may be categorically separated into three parts.

I. Features Pertaining to the History of the Injury. Either from the injured subject himself or, when that is impossible, from any and every other reliable source, the examiner must seek the fullest information on the following points:

A. Time and circumstances of occurrence of the injury.
B. State of consciousness of the injured at the time of and following injury.
C. Any disease or disability existing prior to or at the time of injury.
D. Any treatment previously rendered to the injured.

The time of, and the circumstances under which, the injury was inflicted determine in the main the likelihood of wound infection and the probability of deterioration of the patient's general condition from shock or hemorrhage. The longer the time elapsing from the incidence of the trauma, the greater the prospect of the presence of such complicating factors The circumstances of the injury, particularly the locality where, and the agent by which, the trauma was inflicted are also indicative Those factors also determine the possibility and type of infection and certain considerations of definitive *treatment such as feasibility of primary treatment, extent of any* débridement, and the administration of antitoxins or antibiotics.

Information on the state of consciousness of the subject at the time of and following injury is always essential. A period of unconsciousness following injury always suggests the possibility of intracranial trauma. But it must also be remembered that unconsciousness may have occurred before or at time of the injury from other than traumatic causes and may indeed have been responsible for the injury itself. In this event the examiner must be particularly careful to search for any nontraumatic cause of the unconsciousness.

Pre-existent disease or disability may not only account for the unconscious or comatose state of the injured but for other unexpected findings as well. The possibility of their presence must be kept in mind by the examiner constantly. The presence of such may greatly influence diagnosis, prognosis, and treatment. Alcoholism, diabetes, epilepsy, and cardiac disease, among many others, are familiar examples of conditions which may not only be responsible for the injury directly but which may also be greatly affected by it

Finally, any treatment previously rendered to the injured must be ascertained by the examiner. Too often in the confusion following severe injuries, particularly when several patients are involved, some medication such as morphine or alcohol has been administered without a written record. This may well be forgotten by the patient unless he

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accurate evaluation of the patient's general condition can be made by observation of the rate, depth and rhythm of respiration and the condition of his circulation as evidenced by rate, force, and rhythm of the pulse, color, texture, and moisture of the skin and mucous membrances, and the body temperature, particularly in the extremities.

If any marked embarrassment is noted in either respiration or circulation, it is a wise precaution to begin supportive therapy at once, even at the expense of delaying further examination until proper response is shown. Only when the examiner is satisfied that the patient's general condition is good enough to allow it may he proceed with investigation of the features of the specific injury.

III. Features Pertaining to Character and Extent of the Individual or Specific Injury. Often the nature of the injury is such and the marks of external violence and deformity so obvious in a given body part as to direct the attention of the examiner immediately to that part. Nevertheless, he should usually proceed to the examination in a sequential order and examine the area of the obvious injury in its proper turn. Exceptions to the general rule are instances in which the obvious injuries are such as to require urgent attention and treatment before the examination can be completed; for example, obvious fractures and actively hemorrhaging wounds. In this event he should complete whatever immediate treatment is necessary as rapidly as possible and continue the examination on an orderly basis.

It is usual to begin the examination with the head and progress downward in order—the neck, thorax, abdomen, perineo-genital area, and extremities The ordinary position of the injured subject when under examination is supine, making the anterior body surfaces accessible but concealing the posterior. Neglecting to turn the patient to investigate the posterior aspects may result in failure to recognize obvious and severe trauma concealed by the usual supine position. This is particularly likely to occur in the unconscious or comatose. The examiner, therefore, must take care to examine body parts from all aspects. The experienced examiner of traumatic cases knows that there are certain features common to all injuries regardless of the locality in the body where the injury exists, and that these features, when present, may be detected by the most commonplace clinical methods—inspection, palpation, percussion and auscultation. All of these features indicating the location, character and extent of the injury may not be present in any one injury. Invariably, one or more are present and should warn the examiner to search carefully for the others. Moreover, when one or more of these universal features is noted in a given body part, their presence should stimulate the examiner to investigate fully the anatomy and function of that part for additional information.

Loss of function is an extremely significant finding in determining the location and extent of the injury in any affected part and, therefore, must always be sought for. Moreover, the examiner must be constantly aware of the fact that loss of function in a given part may be produced by co-existent injury to regions remote from the part itself, as, for example, in damage to the central nervous system. In severe injury the nature of the functional impairment may be apparent from observation alone, but it is frequently not so and must be specifically tested for by the examiner. Few errors will occur if he will test the sensory and motor functions of the part and its response to reflex stimulation.

Order of Procedure for Physical Examination of the Injured

The procedure suggested below is one which has proved entirely satisfactory in the management of a large number of traumatic cases and is described here as a method by which most errors can be avoided. It will be noted that this method of procedure is by no means complete and is not advanced as such; it is designed only to help the examiner discover and evaluate immediately the important features of the case in a minimum of time without causing undue harm to the injured:

1. Immediate control of any obvious accessible hemorrhage by pressure or tourniquet, immediate splinting of obvious deformity of the extremities requiring immobilization. Immediate treatment of obvious shock or depleted circulation by administration of supportive measures including intravenous fluid In other words, first attention to obvious conditions which are endangering the patient's life.

2. Removal of all clothing by cutting it away with minimal disturbance of body parts, and the substitution of blankets for the excised garments In brief, make all body parts readily accessible for examination and treatment.

3. Determination, by direct questioning, of the state of consciousness of the injured and thereafter the extent of his co-operability during the examination and the reliability of his statements.

4 Rapid notation of the history of the injury, preferably from the patient himself, or in the event of his inability to co-operate, from the best immediately available source; time and circumstances of occurrence, state of consciousness at and following injury; pre-existing disease or disability and previous treatment rendered—are all minimal essential points in the history But, if information cannot be obtained on all, the examiner must make every effort to establish the two most important—the time of injury and whether or not any narcotic has been administered previously

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otherwise, is given by anyone on the spot and the only agency making a serious attempt to train the general public in proper first-aid measures is the American Red Cross. This organization reaches a great many people and its efforts in this line deserve the co-operative support of the medical profession. It is very easy to criticize first-aid measures and to point out better methods, but one must be in the position of having to give first aid under the conditions existing at the site of an accident to appreciate the problem truly.

The chapter on examination of the patient should be thoroughly digested. With a complete diagnosis, and an accurate evaluation of the general condition of the patient, the battle is half won. Many errors in care are due to incomplete diagnoses, to overlooking some serious injury while concentrating on the obvious. A systematic method of examination will obviate such errors.

Emphasis on the general principles of care of open injuries will be found to run through all the chapters. However, a brief summary of them seems to be appropriate at the beginning of this manual.

The remainder of the manual deals with specific anatomic areas or specific topics. Each chapter is complete in itself, but should be related to others by the reader

It is hoped that the manual will prove valuable to all physicians who have to do with the treatment of injuries. It does not pretend to be a complete treatise nor does it cover the often complicated and specialized aftercare which some injuries require. It is felt, however, that it will serve as a useful guide to the immediate treatment of wounds and will make possible proper carrying out of the initial surgery of the injury on which all else depends

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in the history, general condition, character and extent of the individual injuries are recorded and additional diagnostic and therapeutic procedures ordered. In recording the physical examination, it is necessary in every instance to note the date and hour when it was done and the time at which any treatment was administered during the process.

10. *Transportation of the injured for further definitive treatment.* The patient is not transported until the examiner is satisfied that his general condition permits, any accessible hemorrhage is controlled, and *all parts requiring immobilization are properly splinted.*

In summary, then, it may be said that the most important single feature in early care of traumatic cases is adequate physical examination. The purpose of examination is to provide information as to the general condition of the patient and the extent and nature of the specific injuries, both of which are essential to rational treatment. This information can be reasonably complete on initial examination by *systematized attention to certain common features found in all* injury cases

foreign bodies removed if possible, particularly if they are nonmetallic, all bleeding controlled and the dura and scalp closed snugly. Surgical treatment of these wounds requires experience in brain surgery and special equipment (suction, lighting, electrocoagulation, et cetera). With the use of chemotherapeutic and antibiotic agents, it is permissible to defer operative closure of wounds for many hours pending improvement in the patient's general condition and analysis of his neurologic status.

Leakage of cerebrospinal fluid from the nose or ear constitutes a special problem. Any cerebrospinal fluid fistula invites the risk of meningitis. Now, with an adequate screen of antibiotic and chemotherapeutic agents, one is justified in waiting ten to twelve days pending spontaneous closure. If the leak persists longer than this, surgical closure of the fistula should be considered. Some feel that lowering of the spinal fluid pressure to 90 mm of water by spinal drainage every twelve hours promotes spontaneous closure Fortunately most fistulas close spontaneously.

CLOSED WOUNDS

One of the most frequent causes of death after head injury is progressive cerebral damage due to anoxia. Many factors contribute to this:

1. The capacity of the contused brain to utilize oxygen is diminished.
2. The cerebral blood flow is reduced, even though blood pressure may be elevated.
3. The oxygen concentration of the blood is diminished as the result of a disturbed respiratory center, or obstruction of the respiratory tract (tongue, mucus, pneumonitis)

The treatment in such cases is the maintenance of an adequate airway and the administration of oxygen. Patients frequently improve remarkably after clearing the airway and administering oxygen. The most satisfactory way of giving oxygen is by nasal catheter. Oxygen tents and masks interfere with attempts to keep the airway patent. Constant nursing attention, with a suction apparatus for the removal of mucus, is necessary. This may be supplemented by postural drainage, with the head lowered and the patient lying face down.

The differential diagnosis between surgical and nonsurgical lesions is of primary importance in the management of acute head injuries and usually depends upon the patient's course. Hence, a carefully taken history, particularly as relates to the onset and duration of unconsciousness, and frequent and repeated neurological examinations are necessary.

Intracranial clot, such as extradural, subdural or intracerebral hematoma, usually is incompatible with life and requires surgical re-

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derly or shifted and moved about in bed by well-meaning persons. Any one of these changes in position may lead to serious damage—a fractured spine may sever the cord, a clot may be loosened in a large vessel and lead to hemorrhage, a closed fracture may perforate, a dressing over an open chest wound may shift and a serious respiratory complication occur suddenly.

It is the surgeon's duty to supervise the handling and manipulation of the injured patient at all times, to make certain that no further injury is caused by the various phases of examination, undressing, changes in position, et cetera. He cannot simply order x-rays of this and that part and wait for results. He must be certain that, if x-rays are needed, the necessary manipulations do not cause harm.

V. Care of the Open Wound Itself.

A. *Provide for suitable anesthesia.*

B. *Cleanse the area surrounding the wound and then cleanse the wound itself.* This important phase of care must be done under aseptic precautions with gowns, gloves, and masks. It is not a perfunctory swishing with soap and water but a careful cleansing. The surrounding area is first cleansed, the wound itself being covered with a sterile dressing. The dressing is then removed and, with a fresh set-up, the wound itself is washed and irrigated.

Practices vary somewhat in the selection and use of the cleansing agent. Many surgeons use plain soap and water both for cleansing the skin and for cleansing the wound. Others use soap and water for the skin and simply irrigate the wound with large amounts of normal saline solution. Some surgeons prefer to use one of the mild detergents. One important thing is that the cleansing should be carried out with as careful a technique as the surgeon follows in washing his own hands for operation.

C. *Wound excision and removal of foreign bodies.* The purpose of excision is to remove all hopelessly devitalized tissue. The greatest source of postoperative wound disturbance is necrotic tissue left in the wound at the time of initial care. This is not a wound excision in the sense so often understood, i.e. excision of the whole lining of a wound. The concern of the surgeon here is to remove tissue destined to succumb because of the amount of injury it has sustained. Each tissue is taken in turn and a systematic excision carried out. To be avoided is needless sacrifice of viable tissue The skin especially must be carefully considered. In sharp cutting wounds little if any of the skin border need be excised. In severe crushes and avulsions large areas of skin may be nonviable and require excision. The object is to leave only viable tissue.

Foreign bodies are removed as encountered in the wound.

D. *Deep repair as commensurate with the type of injury.* Here the reader is referred to the various chapters dealing with specific injuries.

prolonged, gastric feedings by nasal catheter are indicated, using a high protein diet.

5. Spinal Puncture. Considerable controversy prevails concerning the indications for and the merit of spinal puncture in the diagnosis and treatment of head injuries. Some advocate daily spinal punctures as routine in the treatment of head injuries, but this is not generally accepted. The authors of this chapter consider the indiscriminate use of spinal punctures dangerous. The following are considered proper indications for spinal puncture:

(a) Diagnostic—
   (1) To determine pressure where intracranial clot is suspected.
   (2) To determine the presence and/or degree of bleeding.
(b) Therapeutic—
   (1) To lessen intracranial pressure by withdrawing fluid as a temporary expedient pending measures that provide more lasting control of increased intracranial tension, such as surgical evacuation of clot
   (2) Evacuation of bloody fluid when signs of meningisimus appear, usually within four to eight days. Evacuation of fluid at this time usually relieves headache and speeds recovery.

Concerning technique, when indicated, a spinal puncture should be done with the patient in the lateral recumbent position, using a standard spinal puncture needle.

The operator should make the following determinations: color of the fluid, initial pressure, final pressure and the amount withdrawn.

Jugular compression tests should not be carried out unless one suspects injury to the spinal column. These tests give no information of value with reference to the brain, and the sudden rise in spinal fluid pressure which follows jugular compression may be harmful after head injury.

Spinal puncture should not be attempted if the patient is uncooperative, for the information obtained is unreliable, and struggling against resistance may be harmful.

6. *Control of Restlessness. Patients who are restless and confused* constitute a difficult nursing problem, and sedative medication may be necessary. Paraldehyde administered rectally, or barbiturates—sodium amytal, sodium luminal—intramuscularly or intravenously are satisfactory. The latter are particularly indicated for the control of convulsions. Morphine and codeine are contraindicated because of depression of respiration, edema of the larynx, and alteration of pupils (diagnostic).

7. Convalescence. Early ambulation is recommended after head injury. The patient should receive physical therapy in the form of active and passive exercises early and should be gotten out of bed into

MANAGEMENT OF ACUTE INJURIES OF THE SPINAL CORD

Because of the Narrow Confines of the spinal canal, the spinal cord is subject to injury from all types of trauma adjacent to, as well as directly involving, the vertebral column. Simple concussion of the cord occurs due to severe trauma in the neighborhood of the spine without actual mechanical compression or disruption of either the bony spine or the cord itself Such spinal cord concussion is accompanied by temporary and reversible interruption of function which does not ordinarily demand any specific therapy. Management includes only careful attention to the skin, bladder and bowels, nutrition and physical rehabilitation as will be outlined subsequently. Recovery often begins within a few hours and is usually maximal, if not complete, within a few weeks.

Aside from concussion and perhaps rare penetrating small missile or knife blade wounds, the treatment of spinal cord trauma must usually be integrated closely with treatment of fracture or fracture-dislocation of the vertebral column It should be emphasized at the outset that these two lesions cannot be managed separately. The surgeon, above all else, must be continually aware of the danger of producing additional spinal cord damage by injudicious manipulation of the patient with a skeletal injury.

Spinal cord injuries may be considered usefully in two major groups, depending on whether they are open or closed. Aspects of treatment which are specific to acute open wounds will first be considered briefly, before discussing management of the commoner types of closed spinal trauma in more detail

TREATMENT OF OPEN INJURIES

Open, or compound, injuries to the cord are relatively rare except in time of war, but occasionally occur in civilian life These open injuries incur the risks of hemorrhage and of wound and meningeal infection in addition to those of direct cord and spine trauma.

Nonfatal penetrating wounds of the cord are usually caused by knife blades, bullets or other missiles, so that puncture wounds rather than gaping lesions are the rule The point of entry through the skin may be at some distance from the point of injury to the cord and may not, therefore, be immediately evident

When first seen, every patient with a penetrating wound of the neck, thorax, abdomen, or back should be checked briefly for sensation, voluntary motion of the extremities and urinary retention to rule out the

Prepared by Donald D. Matson, M.D , F.A C.S , Boston, and sponsored by The Harvey Cushing Society.

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FIRST AID AND EARLY CARE

"First aid is the immediate and temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained. It may mean the difference between life and death, between rapid recovery and long hospitalization, between temporary disability and permanent injury." A physician is present infrequently to render first aid, but he may be, and he needs to know the fundamentals as well as the trained layman. He should be competent to advise on the preparation of first-aid manuals or to instruct first-aid classes, if requested. Further, he must have enough knowledge not to criticize adequate first-aid if he has nothing better to offer There are many first-aid manuals of varying value, but the American Red Cross First-Aid Textbook is probably the most complete, safe and frequently revised. Interns, residents and the general profession should know its content.

Keep an open airway.

All wounds are contaminated. Prevent further contamination by covering with a sterile dressing. Don't use antiseptics. If a period of several hours must elapse before definitive treatment can be given, and soap and running water are available the wound may be washed with these before applying a sterile dressing, except in the case of burns.

External bleeding can almost always be stopped with a pressure dressing Pressure points are not worth considering. Never use a tourniquet unless absolutely necessary as there are undoubtedly more deaths and loss of limbs from the use of a tourniquet than from failing to use one. However, the physician should know how to apply one properly.

If the injured person is found unconscious and has alcohol on his breath, consider that he has a brain injury until proved otherwise. Keep him lying on his side so that his tongue does not fall back causing him to drown in his own secretions

Splint fractures.

Care that all moving is done without further damage to the patient, rather than speed of transportation, is the important criterion. Lives are lost by speed without care.

In this section we can only outline basic principles to prepare the injured person for definitive care in an operating room. This will not include the care of fractures, except as they occur in multiple injuries. The care of injuries of the bones is covered in *An Outline of the Treatment of Fractures*.

Let us assume that a seriously injured person or one with multiple injuries is presented to us. The care of asphyxia, shock and hemorrhage,

Prepared by Robert H. Kennedy, M D , F.A C S., New York, New York.

4. Watertight closure of the dura;
5. Close approximation, in layers, of the rest of the wound.

Operative manipulations of the cord itself, or intradural exploration when the dura is intact, are of no avail.

TREATMENT OF CLOSED INJURIES

Closed spinal injuries in civilian life occur primarily as a result of falls, vehicular accidents, dives in too shallow water, severe convulsive seizures, and occasionally football and skiing accidents. These closed injuries to the spine may produce any degree of cord injury from simple, temporary, entirely reversible concussion to complete crushing or anatomical transection.

From a therapeutic point of view, the significant injuries are those in which fracture or fracture-dislocation result in compression but not division of the spinal cord or cauda equina.

Skeletal injuries which commonly produce spinal cord compression include:

A. Compression Fracture of the Vertebral Body. This type of injury occurs with forced flexion of the spine and may lead to severe angulation or to posterior displacement of an intervertebral disc into the spinal canal. Compression fractures occur most commonly in the middle or low cervical region as a result of falls or blows on the head, and in the thoracolumbar region (T_{12}-L_1) as a result of falls in the sitting position

B. Fracture-dislocation Displacement of one vertebra forward upon another is usually accompanied by fracture and is particularly prone to temporary or persistent compression of the spinal cord. Such a fracture-dislocation may be spontaneously reduced at once but leave residual neurological signs. Dislocations are common at

1. C_1-C_2, in which case there is often a fracture of the odontoid process;
2. C_2-C_3, in which there is often locking of the displaced fragments very difficult to reduce without operation,
3. C_5-C_6 and C_6-C_7, which are commonly produced in diving accidents; and
4. T_{12}-L_1, which are produced by severe blows against the back and by falls in a twisted position.

C. Depressed Fractures These injuries are usually due to local blows directly over the spine. Cord injury results when comminuted fragments of the lamina, spinous process, or pedicles are driven into the spinal canal. They are most common in the thoracic region.

First Aid

It is extremely important to establish as soon as possible after an accident, and before any movement or manipulation of the injured patient is carried out, whether spinal injury is present. This may be

Physical Examination

There may be visible deformity such as forward or rotatory fixation at the site of injury. Edema and ecchymosis sometimes appear quickly and point to the level of fracture or dislocation. The site of injury can often be determined by sliding a hand gently under the patient and examining along the spine for tenderness or palpable deformity. Palpation and percussion for evidence of bladder distention should be part of the general examination.

Neurological Examination

Satisfactory motor, sensory and reflex examination can usually be carried out quickly whether or not the patient is co-operative. Conscious patients can often describe accurately the degree of motor paralysis and the extent of anesthesia or paresthesias.

Motor involvement is determined by testing the strength of voluntary muscular contractions or by involuntary response to painful stimuli

Sensation is tested most satisfactorily by a painful stimulus such as pinprick; this should be carried out from lower toward higher dermatomes in order to determine the level of cord involvement.

Reflexes, both deep tendon and skin, are absent below the level of cord transection immediately after injury. Hyperactive reflexes may indicate cord contusion.

Autonomic disturbance below the level of cord injury is indicated by absence of sweating and vasomotor responses, by loss of voluntary bladder and rectal control, and by priapism.

The neurological picture in cord transection at various levels immediately after spinal injury is briefly outlined.

I. C_2–C_3
  a. Respiratory paralysis.
  b. Complete flaccidity and areflexia
  c. Death in a few minutes unless artificial respiration is maintained.

II C_5–C_6
  a. Paralysis of intercostal respiration.
  b Quadriplegia; complete loss of motor power in trunk and lower extremities; preservation of shoulder girdle function and perhaps some deltoid, pectoral and biceps action.
  c Absent deep tendon reflexes with possible exception of biceps reflex, absent abdominal, cremasteric and plantar reflexes.
  d. Anesthesia below the clavicles and of the ulnar half of the upper extremities at least
  e. Bladder and bowel retention; priapism.

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tion, the blood vessels, the retroperitoneal organs and vessels, the spine and spinal cord, perforation of the diaphragm, etc. Is concealed hemorrhage taking place? We must decide as soon as possible whether any operative procedure is indicated, which part of the body will be approached first when the condition improves sufficiently to do anything, whether any improvement can be expected in the general condition until some intervention has been accomplished, even if the person may die during the attempt.

These decisions may need to be changed as the condition of the patient changes, but we must constantly keep in mind doing first things first. There is no use applying skeletal traction for a fractured femur and spending time carefully arranging traction suspension when we believe the abdomen must be explored at the earliest possible moment, requiring the taking down of the traction apparatus. Rather keep the part in emergency traction until decision is made regarding the abdominal trauma.

X-ray examination is often carried to a ridiculous extent. What films do you absolutely need to determine the optimum time to initiate definitive treatment and the interim care to prevent further injury? Demonstration of free air below the diaphragm may prove rupture of a hollow viscus. Examination for this is of little use unless the patient is in the upright position. The absence of a vertebral column injury may need to be proved before the patient can be supported in the sitting position without danger of spinal cord damage. However, the use of a tilt table allows the examination for free air without endangering the spinal cord.

Too many early x-rays of the skull are taken Unless the patient is cooperative enough to keep his head quiet these should be postponed, unless one believes it is absolutely necessary to determine the presence of an open depressed fracture or of a fracture at a site which could readily produce an injury to the middle meningeal artery. Otherwise no operative intervention on the skull is going to be instituted early and better x-rays for the record may be done later.

The x-ray proof of fractured ribs will usually make little difference in early operative treatment. There may have to be treatment for pain on breathing, for tamponade of the lungs with blood, for paradoxical respiration or tension pneumothorax, but time and effort spent on x-ray of the chest offer little in the early care of the extensively injured that cannot be learned equally well or better by the physical examination. Anesthetizing the proper intercostal nerves often changes the picture entirely in a patient suffering severe chest pain. The blood must be kept oxygenated; adhesive strapping to the chest interferes with this.

Beds in the admission ward are a practical necessity in these cases. Close supervision is necessary. Many patients suffer further injury and exposure during movement from stretcher to x-ray table, ward bed or

days, the persistence of a spinal fluid block as demonstrated by lumbar puncture is indication for an exploratory laminectomy at the site of injury. Actually, persistence of such a block in a patient who does not show x-ray evidence of cord compression or unreduced deformity is very rare.

Definitive Treatment

Definitive care of spinal injuries is directed toward reduction of deformity and relief of cord compression followed by fixation in proper position until satisfactory healing has occurred. As already emphasized, this must be accomplished without further injury to neural tissue.

I. Simple fracture of a vertebral body without compression, or of any other part of a vertebra without displacement, with or without temporary neurological signs, is treated by immobilization in an appropriate plaster cast or brace for at least six to twelve weeks.

II. Compression fracture of one or more vertebral bodies is treated in general by hyperextension of the spine at the level of injury with prolonged fixation in this position.

(A) In the cervical region this is accomplished by traction and extension of the head with sufficient weight (usually from 12 to 15 pounds) until optimum position is reached, followed by continued traction with enough weight (usually from 3 to 5 pounds) to maintain this position for from eight to twelve weeks. The patient may then be transferred to an ambulatory type of plaster neck support or chin-occiput brace for another two to six months.

For prolonged cervical traction, the most effective and comfortable method is afforded by Crutchfield tongs. These are readily inserted under local anesthesia with the patient on a stretcher or bed. After shaving the scalp, two small drill holes are made through the outer table of the skull on either side of the vertex. The tong points are inserted and the lock-nut made secure. A rope is led from the tongs over a pulley projecting from the head of the bed. Countertraction is achieved by elevating the head of the bed on 12-inch blocks. The direction of traction may be altered by adjusting the position of the patient's head and the pulley as desired.

(B) In the thoracolumbar region, hyperextension at the level of injury is achieved by placing the patient on his back over a blanket roll or elevated section of the bed. Maintenance of the correct position is accomplished by application of a plaster body cast.

Forceful hyperextension may be necessary to achieve satisfactory position. It is carried out usually under heavy sedation or anesthesia by

1. suspending the patient face down on a hammock between two tables,
2. lifting the body from the floor with a broad sling at the site of injury, or
3. extension of the patient over a metal strip on an orthopedic table.

Care of Skin

Special measures for skin care should be initiated as soon as the diagnosis of spinal cord injury has been established. In cord transections, pressure areas leading to ischemic necrosis develop with surprising rapidity. It is imperative from the beginning, therefore, to *change the position of the paralyzed parts at least every two hours.* The patient should be placed as soon as possible on a foam rubber or air mattress with great care to protect the sacrum, trochanters, malleoli and heels. If a Stryker frame is available and the patient's skeletal lesion permits its use, frequent changes of position are greatly facilitated.

The entire area of anesthetic skin should be lightly massaged with alcohol, dried carefully, and powdered at least once daily. The bed coverings should be kept dry at all times and as free as possible from wrinkles. After bowel movements or enemas, the perineum and sacral area should be thoroughly cleaned and dried. Frequent application of tincture of benzoin helps protect the skin in areas of pressure. If a decubitus lesion develops, it is imperative that the patient be kept off this region at all times.

Care of Bladder

Retention of urine develops at once after every severe cord injury and because of sensory paralysis may give rise to no discomfort. It is important, therefore, to insert a urethral catheter under aseptic precautions within a few hours after injury to prevent overdistention of the paralyzed bladder. Repeated catheterization should be avoided. A soft rubber catheter of the indwelling variety (size #16 or #18) should be used. If the bladder is already distended it should be decompressed slowly and then left on constant drainage.

As soon as possible a plan of tidal drainage which provides a closed system of automatic, periodic drainage and irrigation of the bladder, should be established. Several satisfactory methods have been devised. In the atonic bladder of acute spinal cord injury, the siphon curve usually should be placed only 1–3 centimeters above the level of the bladder; this position is then checked at intervals by cystometry. Further care of the bladder through the stages of rehabilitation and development of automaticity is not within the scope of this chapter.

Early suprapubic cystostomy for bladder drainage is indicated in patients with local injury, obstruction or infection obviating urethral drainage and under circumstances where installation of regulated, well-supervised tidal drainage must be unduly delayed.

Care of the Bowel

Paralytic ileus is a frequent early and distressing complication of all types of spinal injury and may necessitate use of prostigmine, pitressin,

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Care of the Bowel

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PHYSICAL EXAMINATION OF THE INJURED

Because its findings determine diagnosis, prognosis, and treatment, physical examination is the first and perhaps the most important procedure in the management of any injury. Comprehensively reviewed, the examination is essentially a process of noting the features of the injury and the patient's reaction to it. To do this adequately the examiner must obtain the fullest information possible on the following points:

1. The character and extent of obvious injury,
2. The possibility of any coexistent concealed injuries,
3. The presence of any disability which may be affected by the injury, and
4. The general condition of the injured subject.

Theoretically, the examination of injury cases should be completed with the same careful regard for detail exercised in the examination of those with less urgent complaints. Practically, such detailed examination is seldom possible since the character of the injury, condition of the patient, and inadequacy of facilities frequently place restrictions on the examiner. Disregarding such restrictions in the overzealous attempt to perform complete physical examination upon severe injury cases is likely to result in additional harm and gain slight additional information. Thus the physical examination of injured subjects must in many instances be limited or considerably modified of necessity. But let it be emphatically pointed out that this in no way excuses the examiner from making the fullest examination allowed by the limitations of any individual case.

Certain general precepts obtain in the examination of all cases of trauma. Because they are likely to be unfamiliar to the novice, and frequently neglected by the experienced examiner, they are emphasized as follows:

1. An examination must be made however and wherever possible. The state of consciousness determines, to a very large extent, the amount of accurate information the injured subject can give concerning the circumstances of his injury and his symptoms. It must be remembered that the state of consciousness in traumatic cases may frequently change in very short periods of time. The examiner must therefore take advantage of any conscious interval, wherever or however it occurs, to gain as much information as possible. Regardless of how many examinations have been carried out with the injured subject in a comatose or wholly unconscious condition, additional examination must be made as soon as possible upon return to full or approximately full

Prepared by Robert T. Crowley, M.D., F.A.C.S., New York, and sponsored by the American Association for the Surgery of Trauma.

PRINCIPLES OF TREATMENT IN SEVERE FACIAL INJURIES

In few injuries is the final outcome so directly dependent on proper early care as in the treatment of a severe facial injury. The bony and cartilaginous frame-work of the face supports the soft tissues and teeth, and provides attachment for the muscles of expression and mastication. The character in the face, the emotional expression, and the function of chewing and eating depend upon a normal anatomical and functional relationship between these structures. Failure to restore displaced bone to its normal position or failure to resolve the puzzle of a jagged laceration of the eyelid, nose or mouth, may result in disfigurements which will permanently alter the appearance and function of the face. Only by early adequate reduction of all fractures and adequate splinting of the fragments before fixation of the bones has occurred, can the normal contours of the face be restored and only by accurate layer closure of the soft tissues will function be reestablished and scarring minimized.

The primary problems in the care of all severe injuries of the face are: (1) maintenance of an adequate airway, and (2) arrest of hemorrhage.

The airway may be obstructed by collapse of the mandibular arch which permits the unsupported tongue to fall back against the pharynx; it may be the result of crowding of the tongue by downward or backward displacement of the upper alveolar arch; or it may result from bleeding within the mouth. The tongue can be held forward away from the pharynx by turning the patient on his face, by traction on the tongue with a suture or a safety pin passed through it, or by traction on the displaced bone. Sometimes a McGill tube inserted into the pharynx may be better and more comfortable. Tracheotomy is seldom necessary.

Hemorrhage can usually be controlled by local pressure alone. Packing the open wound with sterile gauze may be necessary. Only if a large artery is torn or severed may immediate ligation be necessary. Shock must be treated appropriately in conjunction with the arrest of hemorrhage. Transfusion or other therapy should be begun promptly.

The next problems are (1) evaluation of the patient's general condition; and (2) evaluation of the extent of the local injury;

Brain damage, injuries of the chest or abdomen and major fractures must often take priority in treatment. The definitive facial repair

Prepared by Bradford Cannon, M.D., F.A.C.S., Boston, and sponsored by the American Board of Plastic Surgery.

Débridement should be minimal, in contrast to the recommended excisions of wounds elsewhere on the body. "It is better to save tissue which may die than to sacrifice any which may survive." The loss of even a small amount of skin about the eyelid or mouth may result in deformity. A piece of skin even though almost completely detached may survive as a free transplant if replaced in its normal position with loose sutures, minimal tension and a firm dressing.

MANAGEMENT OF FRACTURES

Fractures of the facial bones differ from most fractures because the displacement is due to the trauma itself and not to muscular pull. Consequently, the reduction of facial fractures depends on the restoration of the bones to their original position with sufficient fixation to maintain reduction against the minimal elasticity of the soft tissues and the pull of gravity.

Fractures of the mandible are exceptions to the above statement because the fragments are displaced by the very powerful muscles of mastication. In the reduction and fixation of mandibular fractures the pull of these muscles must be counteracted by appropriate fixation.

X-rays of the facial bones are important as a part of the patient's record and to confirm the clinical diagnosis. Proper posing of the head is essential for informative films. The outlines of the rim of the orbits, the zygomatic arches, the lateral and medial walls of the antra, the bony structures of the nose, the alveolar arches and the palate can be visualized in a vertical submental or Water's position. Fractures of the nasal bones are visualized in soft lateral views. Mandibular x-rays should include views of both sides of the jaw, the symphysis and both condyles Questionable fractures of the symphysis or condyles and the direction of fracture lines of the mandible will be revealed.

Reduction of fractures of the facial bones should be treated promptly unless there are urgent reasons for delay. The soft tissue swelling which accompanies a facial injury may mask an underlying fracture unless careful examination and x-ray studies are carried out. The swelling itself is not sufficient reason to delay reduction of the fracture. The facial bones usually solidify within two to three weeks, after which satisfactory reduction may be impossible.

The occlusion of the teeth and the palpable bony prominence of the face are the best guides to the accuracy of the reduction of face and jaw fractures. Simplicity is the essence in the treatment of all facial fractures, both for prompt and lasting relief of the patient's discomfort and for eliminating the need for constant adjustment of complicated appliances.

Most fractures of the mandible can be held in place by direct wiring of the teeth of the upper and lower jaws. An edentulous overriding

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Bearing the above general considerations in mind, it is appropriate to emphasize certain specific features particularly important in the examination of traumatic cases. For comprehensive discussion these features may be categorically separated into three parts.

I. Features Pertaining to the History of the Injury. Either from the injured subject himself or, when that is impossible, from any and every other reliable source, the examiner must seek the fullest information on the following points:

A. Time and circumstances of occurrence of the injury.
B. State of consciousness of the injured at the time of and following injury.
C. Any disease or disability existing prior to or at the time of injury.
D. Any treatment previously rendered to the injured.

The time of, and the circumstances under which, the injury was inflicted determine in the main the likelihood of wound infection and the probability of deterioration of the patient's general condition from shock or hemorrhage. The longer the time elapsing from the incidence of the trauma, the greater the prospect of the presence of such complicating factors The circumstances of the injury, particularly the locality where, and the agent by which, the trauma was inflicted are also indicative Those factors also determine the possibility and type of infection and certain considerations of definitive treatment such as *feasibility of primary treatment, extent of any* débridement, and the administration of antitoxins or antibiotics.

Information on the state of consciousness of the subject at the time of and following injury is always essential. A period of unconsciousness following injury always suggests the possibility of intracranial trauma. But it must also be remembered that unconsciousness may have occurred before or at time of the injury from other than traumatic causes and may indeed have been responsible for the injury itself. In this event the examiner must be particularly careful to search for any nontraumatic cause of the unconsciousness.

Pre-existent disease or disability may not only account for the unconscious or comatose state of the injured but for other unexpected findings as well. The possibility of their presence must be kept in mind by the examiner constantly. The presence of such may greatly influence diagnosis, prognosis, and treatment. Alcoholism, diabetes, epilepsy, and cardiac disease, among many others, are familiar examples of conditions which may not only be responsible for the injury directly but which may also be greatly affected by it

Finally, any treatment previously rendered to the injured must be ascertained by the examiner. Too often in the confusion following severe injuries, particularly when several patients are involved, some medication such as morphine or alcohol has been administered without a written record. This may well be forgotten by the patient unless he

bones from the skull. Support by some type of dental appliance is usually necessary in conjunction with prompt reduction of other bony displacements associated with these fractures. Before union of the bones of the face has become too firm, normal dental occlusion must be restored. Elastic traction between upper and lower teeth by the third week after injury will draw the dental arches together.

MANAGEMENT OF THE SOFT PARTS

All fresh lacerations of the face should be repaired promptly. The healing power of the face is excellent and the resistance to infection high. Success depends on observing certain precautions, the most important of which is to do no additional damage. This includes no unnecessary debridement, no wide sutures which will leave stitch marks, and no excessive tension, especially on flaps of skin with precarious blood supply. All wounds must be thoroughly cleansed, foreign material removed and hematomas evacuated. Closure of the subcutaneous tissues as well as the skin must be done with very fine suture material and all skin sutures should be removed within 48 to 72 hours.

Great care and patience are necessary in replacing the jagged edges of torn and avulsed skin of the eyelids, nose and mouth, especially if the laceration extends through both surfaces of the part with a full-thickness separation of the edges. The fitting together of obscurely misplaced flaps may require several attempts before the correct position is secured. Obvious points of approximation such as the vermilion border, the eyelid margin or the alar margin, are useful as starting points for suturing.

Sutures on the inner surface of the mouth, nose or eyelid should be only enough to secure accurate apposition of the mucosa. Puncture wounds, especially of the lips, are best left unsutured. Free drainage is thus maintained and the likelihood of infection minimized. Small lacerations on the face can sometimes be approximated by adhesive support alone. This method is often preferable in children because anesthesia, sutures, etc. are then unnecessary.

Skin losses can be replaced by a skin graft if the deep tissues are not severely damaged In extensive full thickness losses of the cheek, nose and rarely the eyelid, mucosa and skin may be approximated to close the raw surface in anticipation of later repair.

Suture of branches of the seventh nerve in the face is impractical because the fibers are tiny and identification difficult. If the larger trunks near the angle of the jaw can be identified, suture is indicated. Primary repair of a lacerated Stenson's duct should be considered in injuries of the cheek, but it may have to be postponed.

That secondary revisions of the soft tissues may be necessary in many severe facial injuries must be anticipated in the management of the

INITIAL TREATMENT OF ACUTE INJURIES OF THE EYE

INJURIES OF THE EYE constitute a form of trauma which demands highly specialized care. It is not, unfortunately, a type which permits definitive care by other than trained personnel, even by surgeons who are highly competent in their own specialized fields. The structure of the eye is so detailed, and the surgery required so extremely delicate and so full of potentialities for further damage, that physicians whose acquaintance with ophthalmology is limited, as it usually is, to the general courses given in medical school would seldom wish to cope with it. Furthermore, complete examination of the eye, which is necessary before definitive surgery can be attempted, requires specialized equipment which is not likely to be generally available and with the use of which the non-ophthalmologist would not be acquainted even if he had it at his disposal. The same holds for the very delicate instruments and equipment used in ophthalmic surgery.

On the other hand, if a disaster of magnitude among the civilian population is to be prepared for, as it seems that it must be, civilian methods of ophthalmic practice must be modified to suit the emergency. Ophthalmologists would not be available in sufficient numbers to handle all casualties, nor would the circumstances be auspicious for prompt definitive surgery if they were. It would thus be necessary for general surgeons to be responsible for the initial care of ocular injuries. It would, in fact, be economical of time and personnel if they were to add this responsibility to their responsibility for the care of other injuries, with which, in many instances, ocular injuries are likely to be associated. Many times, indeed, the ocular injuries will be overshadowed by associated injuries which may offer a far greater danger to life.

This chapter has, therefore, been prepared on the realistic assumption that in the event of wartime disasters among the civilian population, the care of ophthalmic casualties would be organized on the same principles as those on which their care was based in World War II: that is, surgeons without special training in injuries of the eye would render first aid and apply other measures designed to counteract the effects of initial trauma, prevent further trauma, and keep the casualty in the status quo, or render him transportable until his care could be assumed by a qualified ophthalmologist.

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accurate evaluation of the patient's general condition can be made by observation of the rate, depth and rhythm of respiration and the condition of his circulation as evidenced by rate, force, and rhythm of the pulse, color, texture, and moisture of the skin and mucous membrances, and the body temperature, particularly in the extremities.

If any marked embarrassment is noted in either respiration or circulation, it is a wise precaution to begin supportive therapy at once, even at the expense of delaying further examination until proper response is shown. Only when the examiner is satisfied that the patient's general condition is good enough to allow it may he proceed with investigation of the features of the specific injury.

III. FEATURES PERTAINING TO CHARACTER AND EXTENT OF THE INDIVIDUAL OR SPECIFIC INJURY. Often the nature of the injury is such and the marks of external violence and deformity so obvious in a given body part as to direct the attention of the examiner immediately to that part. Nevertheless, he should usually proceed to the examination in a sequential order and examine the area of the obvious injury in its proper turn. Exceptions to the general rule are instances in which the obvious injuries are such as to require urgent attention and treatment before the examination can be completed; for example, obvious fractures and actively hemorrhaging wounds. In this event he should complete whatever immediate treatment is necessary as rapidly as possible and continue the examination on an orderly basis.

It is usual to begin the examination with the head and progress downward in order—the neck, thorax, abdomen, perineo-genital area, and extremities The ordinary position of the injured subject when under examination is supine, making the anterior body surfaces accessible but concealing the posterior. Neglecting to turn the patient to investigate the posterior aspects may result in failure to recognize obvious and severe trauma concealed by the usual supine position. This is particularly likely to occur in the unconscious or comatose. The examiner, therefore, must take care to examine body parts from all aspects. The experienced examiner of traumatic cases knows that there are certain features common to all injuries regardless of the locality in the body where the injury exists, and that these features, when present, may be detected by the most commonplace clinical methods—inspection, palpation, percussion and auscultation. All of these features indicating the location, character and extent of the injury may not be present in any one injury. Invariably, one or more are present and should warn the examiner to search carefully for the others. Moreover, when one or more of these universal features is noted in a given body part, their presence should stimulate the examiner to investigate fully the anatomy and function of that part for additional information.

ment from the outset. Incorrect treatment, or undue delay in the application of the proper treatment, may lead to a disastrous outcome in a case in which such an outcome was not originally inevitable. The circumstances of a civilian mass disaster, like the circumstances of warfare, may not always permit ideal ophthalmic care, but the casualty's chances will be greatly improved if an ideal routine of management is planned and is adhered to as closely as possible.

PRINCIPLES OF MANAGEMENT

One of the extremely important ophthalmic lessons learned in World War II should be borne in mind in the event of a civilian disaster in any future war. This lesson is the safety of delay in the management of injuries of the eye, particularly in the management of intraocular foreign bodies, which are present in half or more of all such injuries.

In World War II ophthalmologists were not attached to forward hospitals. Their work was done in hospitals to the rear. Army directives forbade definitive treatment in injuries of the eye until the casualty reached an installation equipped and staffed to render definitive care. The first-aid men who brought the casualty off the battlefield were taught that their task was to get him to a medical officer as promptly as possible. In the meantime, all that they were allowed to do was to remove superficial dirt and debris as gently as possible; cover the eye with sterile pads; instruct the casualty to keep as quiet as possible and under no circumstances to touch his eyes, and then arrange for his evacuation, preferably recumbent, to an evacuation hospital. When the casualty reached this forward hospital, all that the general surgeon who cared for him was permitted to do was to make a diagnosis and to apply such other emergency treatment and measures as were necessary to make him transportable farther to the rear. His definitive care was the business of the ophthalmic surgeon in the base hospital. The responsibility of the surgeon in the forward hospital ended when he had carried out the simple measures just mentioned. His instructions included the admonition to do no more.

The initial care of mass ophthalmic casualties in a civilian disaster should be based upon these bluntly stated principles. General surgeons, for practical reasons, must assume the immediate care of most of these casualties but they should stop at that point. Manuals of first-aid, and even some texts on ophthalmology, describe more or less complicated procedures to be carried out by nurses and even by first-aid workers. They should all be forgotten. The keynote of the early care of ocular injuries by nonophthalmic personnel should be, again to state it bluntly, to limit treatment to absolutely essential first aid and adjunct measures and thereafter to refrain from doing harm.

EXAMINATION

Whether under the circumstances of a civilian military disaster it would be possible to examine the patient's eyes in the ordinary sense of the term, is highly doubtful. The following routine should be observed, however, if it is at all practical.

The examination is best made in a partially darkened room, with a good source of artificial light, such as would be supplied by a gooseneck standing lamp with a 75 to 100 watt frosted bulb. If necessary, examination can be made by daylight. A headlamp is desirable, but a pencil flashlight supplies sufficient illumination for practical purposes. The patient faces the light but is out of its direct rays.

For a detailed examination of the eyeball, the use of some instrument which will magnify the ocular structures by at least two to two and one-half diameters is necessary; the eye is so small that the component parts cannot otherwise be properly identified. If the physician making the examination has available, or knows how to use, a loupe or an ophthalmoscope, that is naturally desirable though it is not particularly likely. Details of the cornea can be made out by a condensing lens supplemented by a beam of light thrown onto the eye while the patient changes his direction of gaze.

Injuries of the eye should be suspected in all head injuries. They should also be suspected in all unconscious patients. Both eyes should always be investigated, even if the history and the gross findings indicate only unilateral injury.

If the patient has other injuries, he must be examined lying down. If he is able to sit up, a more satisfactory examination can be made, particularly if a chair with an adjustable head rest is available.

All movements should be extremely gentle on the part of the physician and the patient should be warned against sudden changes of position. The chances of intra-ocular hemorrhage and loss of vitreous, which are risks in all ocular injuries, can be increased by movement on the part of the patient and carelessness on the part of those attending him. Pressure on a damaged eyeball is extremely dangerous and should be avoided. Probing should never be attempted.

If lid spasm is so great that proper examination is impossible, it may be necessary to instill a local analgesic such as pontocaine (one-half per cent solution) to secure it. The lids are gently separated, spasm being overcome by the use of lid hooks if they are available, or by carefully placed retraction sutures if hooks are not available. Military ophthalmologists have found that sodium pentothal anesthesia is an excellent means of securing relaxation. It is doubtful that a surgeon whose only duty is first aid would be justified in resorting to pentothal, and it is definitely not safe in young children or in elderly persons.

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Loss of function is an extremely significant finding in determining the location and extent of the injury in any affected part and, therefore, must always be sought for. Moreover, the examiner must be constantly aware of the fact that loss of function in a given part may be produced by co-existent injury to regions remote from the part itself, as, for example, in damage to the central nervous system. In severe injury the nature of the functional impairment may be apparent from observation alone, but it is frequently not so and must be specifically tested for by the examiner. Few errors will occur if he will test the sensory and motor functions of the part and its response to reflex stimulation.

Order of Procedure for Physical Examination of the Injured

The procedure suggested below is one which has proved entirely satisfactory in the management of a large number of traumatic cases and is described here as a method by which most errors can be avoided. It will be noted that this method of procedure is by no means complete and is not advanced as such; it is designed only to help the examiner discover and evaluate immediately the important features of the case in a minimum of time without causing undue harm to the injured:

1. Immediate control of any obvious accessible hemorrhage by pressure or tourniquet, immediate splinting of obvious deformity of the extremities requiring immobilization. Immediate treatment of obvious shock or depleted circulation by administration of supportive measures including intravenous fluid In other words, first attention to obvious conditions which are endangering the patient's life.

2. Removal of all clothing by cutting it away with minimal disturbance of body parts, and the substitution of blankets for the excised garments In brief, make all body parts readily accessible for examination and treatment.

3. Determination, by direct questioning, of the state of consciousness of the injured and thereafter the extent of his co-operability during the examination and the reliability of his statements.

4 Rapid notation of the history of the injury, preferably from the patient himself, or in the event of his inability to co-operate, from the best immediately available source; time and circumstances of occurrence, state of consciousness at and following injury; pre-existing disease or disability and previous treatment rendered—are all minimal essential points in the history But, if information cannot be obtained on all, the examiner must make every effort to establish the two most important—the time of injury and whether or not any narcotic has been administered previously

5 Examination of the respiration by observation of the rate, depth and rhythm. All things being equal, changes in the respiration and

3. Injuries of the conjunctiva alone are infrequent because its loose attachment gives it a degree of elasticity which permits it to slide and stretch before the impact of the wounding agent.

4. Double vision suggests injury to the extraocular muscles or to their nerve supply.

5. Emphysema of the orbital tissues indicates an associated fracture extending into the paranasal sinuses.

6. Enophthalmos suggests a fracture of the roof of the maxillary sinus or orbital floor, with sinking of the orbital contents.

7. The presence of a laceration is presumptive evidence that a foreign body has entered the eye. Prolapse of any portion of the uveal tract or of the vitreous similarly indicates a perforating injury and a possible intra-ocular foreign body.

8. Prolapse of pigmented uveal tissue or of vitreous in a wound of the sclera is diagnosed by the presence of a bead of stringy, viscid material, like the white of an egg. A shallow anterior chamber indicates that aqueous has escaped through a corneal or limbal wound.

9. Loss of vision is complete if there is severe intra-ocular hemorrhage, which will so obscure the retina that none of its details can be visualized. Loss of vision may also indicate injury to the optic nerve, as the result of contusion, concussion, or complete severance. Damage to the optic nerve or hemorrhage into its sheath is often suggestive of a fracture through the apex of the orbit.

Even if the surgeon who is treating the casualty is unaware of the significance of these various findings, he should make careful note of them on whatever record form is provided, as they will be of great significance to the ophthalmologist who will later see the patient.

FIRST-AID MEASURES AND ADJUNCT THERAPY

First-aid measures, as already emphasized, should be limited to those which are absolutely necessary. The eye is gently irrigated with physiologic salt solution or boric acid solution, which will carry away much of the foreign material and debris introduced by the injury. Whatever is left and is not embedded can be removed by the gentle application of a wisp of cotton or perhaps by small forceps. These remarks apply only to superficial foreign bodies. Those within the eye or embedded in the cornea should be left untouched.

If the patient is unconscious and cannot close his own eyelids, they may be closed by placing sutures through the skin and subcutaneous tissues of the upper and lower lids, next to the lash edge, and tying them together. A simpler method is to place a suture through the skin of the upper lid, draw the eyelid down, and anchor the free ends to the cheek with adhesive If the upper lid is missing, the process is reversed.

The protection of the damaged portion of the eye by conjunctival

If the extramarginal lacerations are superficial, only cleansing and simple coaptation are necessary. The edges of the wound are brought together either by interrupted sutures or by butterfly strips of adhesive tape. Simple suture of the edges of the defect is satisfactory if less than a third of the margin of the lid is missing. Deep lacerations are sutured in layers, after thorough cleansing. The conjunctiva and the expansion of the aponeurosis of the levator muscle are brought together with interrupted silk sutures, after which the skin and orbicularis muscle are similarly closed. Even when the wound is contaminated, a moderately heavy pressure dressing will serve as a satisfactory substitute for drainage.

Abrasions

Corneal abrasions may occur from surprisingly trivial causes, such as a scratch with the sharp corner of a piece of paper. They may also follow the removal of a foreign body, or may be caused by various types of military injuries. Most of them heal promptly because the corneal surface, even though it may lose most of its epithelium as the result of even a trivial injury, is capable of complete re-epithelization within 24 hours. Prompt healing, however, does not occur in patients whose upper lids are so constructed that in effect, particularly if edema is present, they create suction between the lid and the globe. Pain is severe and secondary iritis is the rule.

In such cases débridement may be necessary. It is best performed by the ophthalmic surgeon, even though it is a relatively simple procedure. The eye is thoroughly anesthetized. Then, with the lids held apart with a speculum, the loose corneal epithelium is rolled back from the abrasion with a tightly wound cotton applicator. Sometimes only a small rim of normal tissue remains around the limbus, but no matter how extensive the involvement, débridement is continued until all loose epithelium has been removed. The edge of the epithelium left in situ is cauterized with phenol or with a 50 per cent solution of trichloracetic acid applied with a pointed applicator. The original abraded area of cornea is similarly treated if it is infiltrated or infected. In this kind of case atropine or some antibiotic ointment is useful.

Lacerations

Whenever a laceration of the eyelids is present, the eye itself must be carefully inspected for possible damage. Whenever a laceration involves the eyeball, the possibility of an intra-ocular foreign body must be borne in mind

No matter what the diagnosis, no attempt should be made to remove the foreign body or to excise anything at all, including apparent blood clots. Prolapsed iris tissue has the appearance of blood clots, and an

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in the history, general condition, character and extent of the individual injuries are recorded and additional diagnostic and therapeutic procedures ordered. In recording the physical examination, it is necessary in every instance to note the date and hour when it was done and the time at which any treatment was administered during the process.

10. *Transportation of the injured for further definitive treatment.* The patient is not transported until the examiner is satisfied that his general condition permits, any accessible hemorrhage is controlled, and all parts requiring immobilization are properly splinted.

In summary, then, it may be said that the most important single feature in early care of traumatic cases is adequate physical examination. The purpose of examination is to provide information as to the general condition of the patient and the extent and nature of the specific injuries, both of which are essential to rational treatment. This information can be reasonably complete on initial examination by systematized attention to certain common features found in all injury cases

Recent experimental evidence suggests that high concentrations of glucose in the blood stimulate the pituitary gland to produce the adrenocorticotrophic hormone (ACTH). If so, this may explain why the routine described is so effective in the properly selected (early) case.

Thermal Burns

Burns of the eyelid are treated like burns of the skin elsewhere in the body. Irritating medicaments should be avoided. No matter what care is exercised, it is almost inevitable that some of the substance will eventually seep into the eyes. In third degree burns, when extensive loss of skin is inevitable, protection of the eyeball by some one of the measures previously described is of paramount importance.

Burns from flames, as already pointed out, do not ordinarily affect the eyeballs because of the protective effect of the eyelids. The eyes must be carefully examined, however, before this is taken for granted. If there is no objective evidence, probably no injury has been sustained.

Burns which involve the upper face and areas about the eyes present special problems because of the great tendency to early contracture, with deformity of the lids. The best plan is to employ massive sterile dressings over fine-mesh gauze impregnated with petrolatum, in combination with the usual measures to prevent or correct shock and to control pain If the eyeball is undamaged, some ophthalmic ointment is instilled into it and it is included in the dressing, being left undisturbed until the dressing is changed. If there is visible evidence of injury, including mild superficial burns of the conjunctiva and anterior cornea, simple cleansing is all the local treatment necessary except for the application of sulfa or aureomycin ointment or 1 per cent atropine ointment. If there is marked inflammation, mild antiseptic ointments, such as White's bichloride of mercury ointment, may be applied several times daily. Healing is usually quicker than with chemical burns, and there is less tendency for chronic inflammation and late vascularization.

Full thickness burns of the cornea and sclera are infrequent. They are usually caused by spattering of molten metal and are, therefore, relatively small. Severe burns of the lower fornix will be followed by symblepharon unless steps are taken to prevent it. If the burns are of limited extent, it is usually sufficient to have the patient exercise his eyes several times daily in all directions. If they are more extensive, the necessary manipulations must be carried out by the ophthalmologist.

If the patient is unconscious and his eyes are open, suture closure may be necessary.

Some of the more severe burns of the eye may be treated with hydrosulphosol in oil, with gentle pressure dressings. There is no general agreement about the advantages of this regimen. Healing is frequently satisfactory but is not remarkable.

When the irrigations are concluded, some analgesic agent is introduced to control pain and blepharospasm. Pontocaine is particularly useful because of its hardening effect on the corneal epithelium. Fluorescein is then applied and the eye is flushed with physiologic salt solution. This procedure is repeated twice. If at the end of the third application no stain is present, it may be concluded that a true chemical burn, in the sense of cell damage, has not occurred. If staining is still present, the patient must have competent ophthalmic care as soon as possible. With application of pontocaine (0.5 per cent) and of ointment containing bacitracin or aureomycin, healing usually occurs within from 24 to 48 hours, though it is not possible to say in which cases it will or will not occur. Cortisone ointment has been found to be of some value. Hydrosulphosol is about as effective as in thermal burns, which means that it is not highly recommended.

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foreign bodies removed if possible, particularly if they are nonmetallic, all bleeding controlled and the dura and scalp closed snugly. Surgical treatment of these wounds requires experience in brain surgery and special equipment (suction, lighting, electrocoagulation, et cetera). With the use of chemotherapeutic and antibiotic agents, it is permissible to defer operative closure of wounds for many hours pending improvement in the patient's general condition and analysis of his neurologic status.

Leakage of cerebrospinal fluid from the nose or ear constitutes a special problem. Any cerebrospinal fluid fistula invites the risk of meningitis. Now, with an adequate screen of antibiotic and chemotherapeutic agents, one is justified in waiting ten to twelve days pending spontaneous closure. If the leak persists longer than this, surgical closure of the fistula should be considered. Some feel that lowering of the spinal fluid pressure to 90 mm of water by spinal drainage every twelve hours promotes spontaneous closure Fortunately most fistulas close spontaneously.

CLOSED WOUNDS

One of the most frequent causes of death after head injury is progressive cerebral damage due to anoxia. Many factors contribute to this:

1. The capacity of the contused brain to utilize oxygen is diminished.
2. The cerebral blood flow is reduced, even though blood pressure may be elevated.
3. The oxygen concentration of the blood is diminished as the result of a disturbed respiratory center, or obstruction of the respiratory tract (tongue, mucus, pneumonitis)

The treatment in such cases is the maintenance of an adequate airway and the administration of oxygen. Patients frequently improve remarkably after clearing the airway and administering oxygen. The most satisfactory way of giving oxygen is by nasal catheter. Oxygen tents and masks interfere with attempts to keep the airway patent. Constant nursing attention, with a suction apparatus for the removal of mucus, is necessary. This may be supplemented by postural drainage, with the head lowered and the patient lying face down.

The differential diagnosis between surgical and nonsurgical lesions is of primary importance in the management of acute head injuries and usually depends upon the patient's course. Hence, a carefully taken history, particularly as relates to the onset and duration of unconsciousness, and frequent and repeated neurological examinations are necessary.

Intracranial clot, such as extradural, subdural or intracerebral hematoma, usually is incompatible with life and requires surgical re-

Patients with wounds which do not involve the important structures outlined above are treated as follows:

1. Protect the open wound with a sterile dressing while cleansing a wide surrounding area with plain soap and water. Hairy parts are shaved.
2. Infiltrate the margins of the wound through the intact skin with a one per cent solution of procaine.
3. Cleanse the wound and excise devitalized tissue.
4. Close the wound with the least number of interrupted nonabsorbable sutures necessary for adequate approximation without tension.
5. Apply a sterile dressing and supporting bandage.
6. Tetanus antitoxin, or tetanus toxoid, and antibiotic medication should be given when circumstances and the nature of the wound warrant this treatment.

Constricting bandages should not be applied to the neck of any patient who is unconscious, or may become so following medication, unless there is someone in attendance to guard against strangulation from hemorrhage, edema, or any other cause for tracheal obstruction or venous compression.

It is sometimes advisable to transport these patients in a prone position when the presence of tracheal or esophageal injuries renders possible fatal aspiration of secretions, vomitus, or blood.

In the case of patients who require more adequate facilities, the wound should be covered with a sterile dressing of appropriate size, and the patient should then be sent to a hospital where the care necessary for such wounds is available. Even in the well equipped emergency room probing of neck wounds and removal of blood clots should not be done unless one is prepared to control hemorrhage and supply blood in a volume sufficient to prevent or overcome shock. However, the urgent case must be cared for promptly.

Injuries to Air Passages

Respiratory obstruction may result from aspiration of blood or a foreign body, direct trauma to the larynx or trachea, edema due to injuries to adjacent structures in the neck or floor of the mouth, or increased pressure in the neck due to hemorrhage from an artery, large or small.

Respiratory obstruction when impending, or likely to occur from the nature of the neck wound, warrants immediate hospitalization lest an urgent condition be precipitated. Morphine should not be given to a patient with impending obstruction.

When strangulation is already present or developing, immediate tracheotomy is necessary. Done soon enough, even under the most unfavorable circumstances, it may be lifesaving. Inspiratory indrawings at the suprasternal notch, supraclavicular fossae and epigastrium, indicates the urgency of the condition.

When possible, the advice and services of a laryngologist should be sought for the care necessary to prevent the sequelae of these injuries.

Injuries to Vessels

Bleeding from superficial vessels is controlled by ligation. When injury to a large vessel is suspected or actually present, manipulation of the wound should be avoided lest disturbance of a protective blood clot result in uncontrollabel hemorrhage. Care of injuries to large vessels requires blood for replacement, intratracheal anesthesia, oxygen, adequate assistance to aid in exposure of the wound and control the blood flow in the carotid, or innominate or subclavian arteries (and one or two of these vessels may require control to help locate and ligate a bleeding vessel or vessels), suture material and instruments of proper *size and design, adequate lighting, and nursing care.*

Unless these facilities are available, and pending transportation to a hospital, the wound should be covered with a *compression dressing* held in place by adhesive tape which does not encircle the neck, or by manual compression.

Penetrating or perforating wounds of small size associated with severance or perforation of large vessels may be accompanied by little or no external bleeding. The neck becomes swollen because of venous compression and accumulation of blood in the fascial spaces. This is commonly associated with difficulty in breathing due in part to tracheal compression and in part to factors associated with increased pressure in the neck but not related to a decrease in size of the airway.

It is of some value to distinguish between strangulation due to a defect in the airway and strangulation due to internal tension in the neck. Decompression of the fascial spaces by incision into them will relieve the respiratory difficulty, but the bleeding point must now be controlled lest fatal hemorrhage ensue. Intratracheal anesthesia with a high oxygen content is extremely useful. Operating procedure is as follows:

1. Skin incision over the anterior border of the sternomastoid muscle on the side of the injured vessel.
2. Compression by stick sponge over site of injury.
3. Isolation of carotid artery below the wound with application of tape sling.
4. Isolation of carotid artery and jugular vein above the injured site with application of tape slings.
5. Exposure of the injured segment of vessel, and wound cleansed of clots, loose tissue, and tags.
6. Closure of artery wound either by a continuous nonabsorbable suture (0000 on needle) or ligation with a braided silk ligature close to adjacent branches with removal of the damaged segment. The smaller the caliber of the artery the finer the ligature necessary to occlude the lumen. Veins are ligated close to branches to avoid sacs of non-

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prolonged, gastric feedings by nasal catheter are indicated, using a high protein diet.

5. SPINAL PUNCTURE. Considerable controversy prevails concerning the indications for and the merit of spinal puncture in the diagnosis and treatment of head injuries. Some advocate daily spinal punctures as routine in the treatment of head injuries, but this is not generally accepted. The authors of this chapter consider the indiscriminate use of spinal punctures dangerous. The following are considered proper indications for spinal puncture:

(a) Diagnostic—
  (1) To determine pressure where intracranial clot is suspected.
  (2) To determine the presence and/or degree of bleeding.
(b) Therapeutic—
  (1) To lessen intracranial pressure by withdrawing fluid as a temporary expedient pending measures that provide more lasting control of increased intracranial tension, such as surgical evacuation of clot
  (2) Evacuation of bloody fluid when signs of meningisimus appear, usually within four to eight days. Evacuation of fluid at this time usually relieves headache and speeds recovery.

Concerning technique, when indicated, a spinal puncture should be done with the patient in the lateral recumbent position, using a standard spinal puncture needle.

The operator should make the following determinations: color of the fluid, initial pressure, final pressure and the amount withdrawn.

Jugular compression tests should not be carried out unless one suspects injury to the spinal column. These tests give no information of value with reference to the brain, and the sudden rise in spinal fluid pressure which follows jugular compression may be harmful after head injury.

Spinal puncture should not be attempted if the patient is uncooperative, for the information obtained is unreliable, and struggling against resistance may be harmful.

6. CONTROL OF RESTLESSNESS. Patients who are restless and confused constitute a difficult nursing problem, and sedative medication may be necessary. Paraldehyde administered rectally, or barbiturates—sodium amytal, sodium luminal—intramuscularly or intravenously are satisfactory. The latter are particularly indicated for the control of convulsions. Morphine and codeine are contraindicated because of depression of respiration, edema of the larynx, and alteration of pupils (diagnostic).

7. CONVALESCENCE. Early ambulation is recommended after head injury. The patient should receive physical therapy in the form of active and passive exercises early and should be gotten out of bed into

healing occurs without suture, but repair of large rents is desirable in order to avoid persistent leakage of secretions. Feeding through a nasal catheter is desirable for a period of a few days to one week, depending on the size of the opening. Extensive wounds of the pharynx or esophagus may heal better without an indwelling catheter. The establishment of a gastrostomy or jejunostomy may better accomplish maintenance of nutrition without interfering with the healing process in the neck. Following necessary care at the site of injury, the skin is closed loosely, and a drain put into the fascial space.

Wounds Adjacent to Jaws, Chest, Axilla, Head

The bony barrier between the neck and chest is the first rib on each side, attached to the sternum. The bony barrier between the neck and axilla is the clavicle on each side. These barriers between adjacent zones of soft tissue interfere with the freedom of manipulation which is frequently necessary to cope with wounds of the neck extending to the chest or axilla.

The floor of the mouth and mandible are also frequently injured in wounds involving the neck. Thus, these zones adjacent to the neck must be studied and, when necessary, exposed in order to complete the care of injuries to important structures (blood vessels, food and air passages). The control of blood flow in the carotid, innominate and subclavian arteries must not be undertaken lightly in an emergency room. The possibilities of the complications noted above emphasize rather the need for the careful examination, evaluation, and triage of patients with neck wounds.

Concomitant Injuries

Failure to examine the rest of the body of the patient who has a severe neck injury may be cause for an avoidable disability or a fatal issue, even when proper care for the neck wound has been carried out. Thus, the casual survey of the initial examination must be followed by more thorough study by all personnel who are charged with the responsibility for the care of the patient. An unreduced dislocation of a thumb may be insignificant when compared to a life endangering wound in the neck. However, while he may recover from the neck injury, the patient may be left with a disabled hand.

respiratory physiology, the control of hemorrhage, and the prevention of infection. The control of hemorrhage is carried out in essentially the same manner as in other parts of the body and prevention of infection poses no problems peculiar to the thorax, so neither subject is discussed in detail here. On the other hand, certain injuries produce important changes in cardiorespiratory physiology, changes which give rise to characteristic symptoms and signs. It is necessary that the physician who has the responsibility for the care of patients with thoracic injuries be familiar with these physiologic changes, the manner in which they are produced, the physical signs and symptoms associated with them, and, finally, the most effective measures for their relief.

Several all important conditions develop only as a result of chest injuries. These may occur singly or in combination in patients with chest injuries from any cause. Unrecognized and therefore without proper management, the results are necessarily poor. If recognized and their mode of production is understood, treatment may be simple. These conditions are as follows:

1. Retention of bronchial secretions with inadequate pulmonary aeration, caused by:
   a. Severe chest wall pain
   b. Abnormal mobility of the chest wall
   c. Depression of the cough reflex through
      (1) Unconsciousness
      (2) Administration of excessive amounts of opiates
2. Open chest wall with the "sucking sound" phenomenon. A similar condition physiologically is produced by extensive rib fractures with resultant excess mobility of a considerable segment of chest wall, the so-called "flail chest".
3. Pressure or tension pneumothorax with or without mediastinal emphysema.
4. Cardiac tamponade.
5. Massive hemothorax.

Since adequate treatment of these conditions will correct the resulting cardiorespiratory disturbances and thereby aid in resuscitation of the patient, each condition will be discussed in some detail.

Chest wall pain may have serious consequences in injuries which otherwise would be of no great importance. Pain may effectively immobilize the chest wall, thereby making cough ineffectual. This results in retention of tracheobronchial secretions and/or aspirated material. The accumulation of such material in the bronchi interferes with pulmonary ventilation and leads to atelectasis and perhaps even to suppurative pneumonitis If inadequately treated, such patients may actually go on to asphyxiation. Recognition of such a situation is not difficult.

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MANAGEMENT OF ACUTE INJURIES OF THE SPINAL CORD

Because of the Narrow Confines of the spinal canal, the spinal cord is subject to injury from all types of trauma adjacent to, as well as directly involving, the vertebral column. Simple concussion of the cord occurs due to severe trauma in the neighborhood of the spine without actual mechanical compression or disruption of either the bony spine or the cord itself Such spinal cord concussion is accompanied by temporary and reversible interruption of function which does not ordinarily demand any specific therapy. Management includes only careful attention to the skin, bladder and bowels, nutrition and physical rehabilitation as will be outlined subsequently. Recovery often begins within a few hours and is usually maximal, if not complete, within a few weeks.

Aside from concussion and perhaps rare penetrating small missile or knife blade wounds, the treatment of spinal cord trauma must usually be integrated closely with treatment of fracture or fracture-dislocation of the vertebral column It should be emphasized at the outset that these two lesions cannot be managed separately. The surgeon, above all else, must be continually aware of the danger of producing additional spinal cord damage by injudicious manipulation of the patient with a skeletal injury.

Spinal cord injuries may be considered usefully in two major groups, depending on whether they are open or closed. Aspects of treatment which are specific to acute open wounds will first be considered briefly, before discussing management of the commoner types of closed spinal trauma in more detail

TREATMENT OF OPEN INJURIES

Open, or compound, injuries to the cord are relatively rare except in time of war, but occasionally occur in civilian life These open injuries incur the risks of hemorrhage and of wound and meningeal infection in addition to those of direct cord and spine trauma.

Nonfatal penetrating wounds of the cord are usually caused by knife blades, bullets or other missiles, so that puncture wounds rather than gaping lesions are the rule The point of entry through the skin may be at some distance from the point of injury to the cord and may not, therefore, be immediately evident

When first seen, every patient with a penetrating wound of the neck, thorax, abdomen, or back should be checked briefly for sensation, voluntary motion of the extremities and urinary retention to rule out the

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If the size of the opening approaches or exceeds the size of the glottis, the patient may get into serious difficulty. Other important factors are the type of wound and the mobility of the mediastinum. If the wound allows air to enter the pleural space but does not permit it to escape, the patient's condition deteriorates more rapidly. Since the mediastinum is usually quite mobile, open pneumothorax generally leads to a shift of the mediastinum to the opposite side with compression of the contralateral lung as well as the lung on the side of injury. The swing of the mediastinum with each respiratory cycle causes poor air exchange and also interferes with the return of venous blood to the heart.

Smaller wounds of this type which give rise to the characteristic sound of air entering or being expelled from the chest have long been known as "sucking wounds." Since this term has no significance apart from the altered physiology of an open pneumothorax, and since wounds often change from the closed to the open type, or vice versa, with changes in tissue plane alignment, there seems to be no logical reason to retain the term. All penetrating injuries of the chest wall are to be considered open (sucking) until careful inspection or actual débridement prove them to be otherwise.

Open wounds must be closed effectively as soon as possible. As an emergency measure a simple occlusive dressing of vaseline gauze is adequate. When the patient has been removed to a location where facilities are adequate, the wound is débrided and an airtight pleuromuscular closure is done. A large catheter (34F–45F) is inserted through an intercostal space into the pleural cavity and is connected to a water-seal arrangement (for evacuation of air and fluid). The wound will be discussed later.

Flail chest is always a serious occurrence and, if the mobilized segment of chest wall is large, it may even be life-endangering. Milder cases are adequately handled by intercostal nerve block supplemented by a stabilizing pressure dressing secured by elastic adhesive. More serious injuries may require the insertion under aseptic precautions of a sterile towel clip around the central rib of the flail segment and the application of light traction. Traction may be obtained by a cord attached to a weight, usually about five pounds, suspended over a single pulley attached to an overhead frame. The intercostal nerves of the involved area should be injected with procaine. Oxygen should be administered.

The terms "pressure" or "tension pneumothorax" indicate the accumulation of sufficient air in the pleural cavity to compress the lung and thereby seriously interfere with ventilation. If the mediastinum is not fixed by adhesions, the opposite lung may also be compressed.

Patients with pressure or tension pneumothorax are usually dyspneic and cyanotic. The combination of hypoxia and interference with

thorax. Such a combination usually indicates a serious underlying injury. Collections of air limited to the subcutaneous tissues may reach startling proportions but fortunately, in the absence of gas-forming pathogens, seldom endanger life. Air under pressure in the mediastinum interferes with the venous return and may also cause tracheal obstruction.

Air gains access into the mediastinum through perforations of the esophagus, the trachea or mediastinal portions of the main stem bronchi. Also air may dissect along the bronchi and/or blood vessels and gain access to the mediastinum from the lung. In extensive mediastinal emphysema there is apt to be swelling of the neck. In some cases the mediastinal emphysema is associated with subcutaneous air. The diagnosis of mediastinal emphysema is made by hearing the so-called "mediastinal crunch" with the stethoscope and visualizing the air by roentgenography. In cases where air dissects up into the base of the neck the distinctive crepitation produced by air in the tissues is easily elicited.

Treatment should be directed toward correction of the underlying lesion. If a tension pneumothorax is present, a catheter is inserted into the pleural space and is connected to a water-seal device. If air is present in the mediastinum under sufficient pressure to cause labored respirations and circulatory impairment, a collar type incision should be made at the base of the neck and a finger introduced into the superior mediastinum, thereby permitting the ready escape of air. If the air in the mediastinum is the result of laceration of the trachea or esophagus, open thoracotomy is indicated.

Massive accumulations of blood in the pleural cavity may produce serious physiologic disturbances, as well as the effects of blood loss. These physiologic disturbances may be reductions in lung volume and vital capacity, reduced cardiac filling from obstruction of the mediastinal veins, and compression of the contralateral lung, the result of mediastinal shift. Recognition of these conditions is not difficult. These patients show dyspnea and pallid cyanosis, the percussion note is flat, and the breath and voice sounds are usually distant over the greater part of the chest, but the breath sounds may have a bronchial character posteriorly near the spine. Thoracentesis which produces a free return of blood confirms the diagnosis.

Treatment is directed toward evacuation of blood from the pleural cavity and restoration of the blood volume. Initially, sufficient blood should be removed to relieve the respiratory distress and mediastinal venous obstruction. Meantime, sufficient blood should be administered to restore the blood volume and content to normal. In an emergency, blood from the pleural cavity may be citrated, filtered and autotransfused if there is no gross contamination, and if the injury is of short

thorax. Such a combination usually indicates a serious underlying injury. Collections of air limited to the subcutaneous tissues may reach startling proportions but fortunately, in the absence of gas-forming pathogens, seldom endanger life. Air under pressure in the mediastinum interferes with the venous return and may also cause tracheal obstruction.

Air gains access into the mediastinum through perforations of the esophagus, the trachea or mediastinal portions of the main stem bronchi. Also air may dissect along the bronchi and/or blood vessels and gain access to the mediastinum from the lung. In extensive mediastinal emphysema there is apt to be swelling of the neck. In some cases the mediastinal emphysema is associated with subcutaneous air. The diagnosis of mediastinal emphysema is made by hearing the so-called "mediastinal crunch" with the stethoscope and visualizing the air by roentgenography. In cases where air dissects up into the base of the neck the distinctive crepitation produced by air in the tissues is easily elicited.

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4. Watertight closure of the dura;
5. Close approximation, in layers, of the rest of the wound.

Operative manipulations of the cord itself, or intradural exploration when the dura is intact, are of no avail.

TREATMENT OF CLOSED INJURIES

Closed spinal injuries in civilian life occur primarily as a result of falls, vehicular accidents, dives in too shallow water, severe convulsive seizures, and occasionally football and skiing accidents. These closed injuries to the spine may produce any degree of cord injury from simple, temporary, entirely reversible concussion to complete crushing or anatomical transection.

From a therapeutic point of view, the significant injuries are those in which fracture or fracture-dislocation result in compression but not division of the spinal cord or cauda equina.

Skeletal injuries which commonly produce spinal cord compression include:

A. Compression Fracture of the Vertebral Body. This type of injury occurs with forced flexion of the spine and may lead to severe angulation or to posterior displacement of an intervertebral disc into the spinal canal. Compression fractures occur most commonly in the middle or low cervical region as a result of falls or blows on the head, and in the thoracolumbar region (T_{12}-L_1) as a result of falls in the sitting position

B. Fracture-dislocation Displacement of one vertebra forward upon another is usually accompanied by fracture and is particularly prone to temporary or persistent compression of the spinal cord. Such a fracture-dislocation may be spontaneously reduced at once but leave residual neurological signs. Dislocations are common at

1. C_1-C_2, in which case there is often a fracture of the odontoid process;
2. C_2-C_3, in which there is often locking of the displaced fragments very difficult to reduce without operation,
3. C_5-C_6 and C_6-C_7, which are commonly produced in diving accidents; and
4. T_{12}-L_1, which are produced by severe blows against the back and by falls in a twisted position.

C. Depressed Fractures These injuries are usually due to local blows directly over the spine. Cord injury results when comminuted fragments of the lamina, spinous process, or pedicles are driven into the spinal canal. They are most common in the thoracic region.

First Aid

It is extremely important to establish as soon as possible after an accident, and before any movement or manipulation of the injured patient is carried out, whether spinal injury is present. This may be

ing. If the wound is left open, the wound edges are covered with fine mesh gauze and an adequate dressing applied. If the pleural space has not been opened by the injury, débridement should be so carried out as to preserve its integrity.

If the pleura has been penetrated, foreign material loose in the pleural space and devitalized tissues are sought out and carefully removed. Lacerations of the lung should be sutured. Large quantities of warm physiological saline solution are used to lavage the pleural space. Antibiotics are applied intrapleurally, and an airtight closure of the chest wall defect is made, if necessary by the use of pedicled muscle flaps. Drainage is obtained by placing catheters (34F–45F) in the intercostal spaces anteriorly and posterolaterally connecting each catheter with an under water-seal system. Suction is seldom indicated during the first forty eight hours after operation.

Intrathoracic Bleeding. Intrathoracic bleeding must be controlled. Continued bleeding is often from the intercostal or internal mammary vessels, and, if it is not possible to control it by other means, thoracotomy is necessary. Injury to the larger systemic intrathoracic vessels, such as the aorta, is generally rapidly fatal, but patients occasionally survive injury to large pulmonary vessels. Continued severe bleeding from the smaller vessels of the lung is of infrequent occurrence. Careful appraisal of all the problems presented is necessary in making the decision as to whether to do a thoracotomy. Features which aid in the decision regarding thoracotomy are: (a) rapid reaccumulation of blood in the pleural space (removal of as much as 2000 cc. of blood within 24 hours does not afford proof of continuing bleeding but does strongly suggest it); and (b) patients in shock who do not show continued improvement following the administration of what would seem to be adequate amounts of blood. For example, if the blood pressure fails to rise to a relatively normal level (above 100 mg. Hg. systolic) after 1500 to 2000 cc. of blood or shows only a transient rise after such an amount of blood, thoracotomy is in order.

Thoraco-abdominal Injuries. Thoracic injuries without continued bleeding or complicated by other important injuries rarely show persistent shock when the disturbances in cardiorespiratory physiology have been corrected The individual with thoracic injury who shows persistent shock in the absence of serious extrathoracic wounds should be suspected of having continued bleeding or gross contamination of the peritoneal and/or pleural spaces, possibly the result of transdiaphragmatic visceral injury. Blood and bile may be sucked into the chest in right-sided thoraco-abdominal wounds. Prompt operation is required in such patients. Continued bleeding due to injury of the heart is discussed elsewhere.

Intra-abdominal hollow viscus perforation or injury of a solid organ

evidence of esophageal perforation cannot be established, large doses of antibiotics are given and the patient is observed for a few hours. If the patient's condition deteriorates, prompt thoracotomy is indicated. The perforation in the esophagus is sutured, the mediastinal pleura is left open and drainage of the pleural space is established through two catheters (34F–45F), one inserted through an anterior interspace, the other posterolaterally. Each catheter is connected with a water-seal system

ACCUMULATION OF AIR IN THE THORAX. The rapid and progressive accumulation of air in the thorax usually indicates injury of one of the large bronchi or intrathoracic portion of the trachea and is an indication for immediate surgery. Simple tension or pressure pneumothorax is considered elsewhere. Failure of the lung to expand is an indication of such an injury. Repair of injury to a large bronchus or trachea may be accomplished by using interrupted sutures to close the laceration and then by reinforcing the suture with a flap of mediastinal pleura. If repair is not feasible, excision of the affected lobe or lung may be necessary. When pulmonary resection is necessary the proximal bronchus is closed with interrupted fine silk suture. If the patient's condition is precarious, proximal mass ligation may be life saving until facilities are available for definitive surgery.

Patients with associated injuries of other organs or parts, for instance the urinary tract, head, or extremities, which may also require early surgery, will usually be given a better change for recovery if the thoracic injuries are treated before other operative procedures are undertaken. When there are associated injuries of the extremities, the patient should not be immobilized in a manner which will interfere with coughing and clearing the tracheobronchial tree of secretions.

CARDIAC INJURIES. The heart may be injured by nonpenetrating, penetrating, or perforating thoracic injuries. Contusion of the heart probably occurs more frequently than is realized and, rarely, rupture of one of the cardiac chambers occurs as the result of heavy blows or crushing force over the precordium. However, the great majority of heart wounds are the result of penetrating or perforating wounds. Penetrating wounds often give rise to cardiac tamponade, in which case there may be little actual blood loss. Perforating wounds of the heart usually result in massive hemorrhage into one of the pleural cavities and occasionally to the outside, but in perforating wounds of one of the ventricles, blood may escape from the heart more rapidly than from the pericardial sac, thus producing the picture of [illegible] tamponade plus severe blood loss. It is important that this [illegible] situation be recognized at once.

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Physical Examination

There may be visible deformity such as forward or rotatory fixation at the site of injury. Edema and ecchymosis sometimes appear quickly and point to the level of fracture or dislocation. The site of injury can often be determined by sliding a hand gently under the patient and examining along the spine for tenderness or palpable deformity. Palpation and percussion for evidence of bladder distention should be part of the general examination.

Neurological Examination

Satisfactory motor, sensory and reflex examination can usually be carried out quickly whether or not the patient is co-operative. Conscious patients can often describe accurately the degree of motor paralysis and the extent of anesthesia or paresthesias.

Motor involvement is determined by testing the strength of voluntary muscular contractions or by involuntary response to painful stimuli

Sensation is tested most satisfactorily by a painful stimulus such as pinprick; this should be carried out from lower toward higher dermatomes in order to determine the level of cord involvement.

Reflexes, both deep tendon and skin, are absent below the level of cord transection immediately after injury. Hyperactive reflexes may indicate cord contusion.

Autonomic disturbance below the level of cord injury is indicated by absence of sweating and vasomotor responses, by loss of voluntary bladder and rectal control, and by priapism.

The neurological picture in cord transection at various levels immediately after spinal injury is briefly outlined.

I. C_2–C_3
- a. Respiratory paralysis.
- b. Complete flaccidity and areflexia
- c. Death in a few minutes unless artificial respiration is maintained.

II C_5–C_6
- a. Paralysis of intercostal respiration.
- b Quadriplegia; complete loss of motor power in trunk and lower extremities; preservation of shoulder girdle function and perhaps some deltoid, pectoral and biceps action.
- c Absent deep tendon reflexes with possible exception of biceps reflex, absent abdominal, cremasteric and plantar reflexes.
- d. Anesthesia below the clavicles and of the ulnar half of the upper extremities at least
- e. Bladder and bowel retention; priapism.

Wounds of the heart should be operated upon promptly under the following circumstances:

1. When tamponade cannot be relieved by pericardicentesis because of clotting of blood within the pericardial sac;
2. When tamponade, due to failure of the wound to seal off, continues or recurs rapidly; or
3. When bleeding into the chest cavity or to the outside continues.

Otherwise heart wounds should be treated conservatively, at least until the operation (including pericardicentesis) can be performed under satisfactory conditions.

CARDIORRHAPHY. If differential pressure anesthesia is available, a transpleural approach through a long incision in the third and fourth intercostal spaces anteriorly is preferable. If additional exposure is necessary, the adjacent cartilages may be divided at the sternum. Where proper facilities are not available for differential pressure anesthesia, the operation may be performed extrapleurally under regional block and local infiltration anesthesia. When the latter method is employed, a curved, left parasternal incision is best, and usually three cartilages and segments of the corresponding ribs (three, four and five) are resected subperiosteally. The internal mammary vessels and the corresponding intercostal arteries are ligated and the prepericardial areolar tissue is incised perpendicularly near the sternal border and dissected to the left, carrying the pleural fold with it. The pericardium is opened widely, the blood is removed by suction, and the wound is located. Bleeding is controlled by pressure over the wound with the index finger of the left hand and a deep traction suture is passed beneath the compressing finger. Slight traction on this suture will largely control bleeding while the approximating sutures are placed and tied. The traction suture is then removed. Cardiorrhaphy is best done with interrupted sutures of medium, 000 or 0000 silk on a slender curved needle. Apical traction sutures should be employed only when the wound is difficult of exposure. The pericardium is closed with a few widely spaced interrupted sutures. In the presence of excessive cardiac irritability the intrapericardial injection of 10 cc. of two per cent procaine is advisable. Drains are not placed within the pericardial sac.

In rare instances patients with wounds perforating the pericardium and heart will survive for considerable periods. Such cases may lead to confusion and delay because of the combination of signs of cardiac tamponade and massive hemothorax. This combination of findings indicates a grave prognosis, but, if conditions permit, thoracotomy and cardiorrhaphy should be undertaken immediately. The transpleural approach through a long intercostal incision can be executed more rapidly and gives a more adequate exposure for repair of the posterior heart wound.

EARLY CARE OF INJURIES TO THE ABDOMEN

INTRODUCTION

William F. MacFee, M.D., F.A.C.S., New York

EARLY CARE OF INJURIES TO THE ABDOMEN depend first of all upon early recognition and correct appraisal. When the injury is of the penetrating variety, its probable nature and the structure involved are more readily surmised than when the injury has been produced by a nonpenetrating force. If it is suspected that a penetrating wound involves the peritoneal cavity, it is mandatory to explore the abdomen with the least possible delay.

When the abdomen has been injured by a nonpenetrating force, there is often a question as to whether the injury involves intra-abdominal viscera. A satisfactory answer requires exceptional diagnostic acumen. The significance of important symptoms and signs must be recognized early if the necessary surgical measures are to be taken in time to be effective or, on the other hand, if the patient is to be spared an unnecessary operation.

Abdominal injuries as a rule involve a number of different structures, such as blood vessels, hollow viscera, and solid organs. In a discussion of abdominal trauma it is obviously impossible to include all the possible combinations of injuries

The tentative diagnosis of penetrating wounds of the digestive tube is usually not difficult. The presence of a wound of entry and a wound of exit, if such exists, and a knowledge of the causative agent often provide sufficient evidence for a presumptive diagnosis of such injury. The organs most likely to be involved naturally depend upon the course of the missile, which usually is straight, or upon the thrust of the penetrating instrument. The absence of a wound of exit in the case of bullet wounds, or the lack of factual data concerning the type of weapon in stab or cutting types of wounds, may increase the difficulties of assaying the extent and location of internal injury.

If there is a question as to whether the wounding agent has actually entered the abdominal cavity, this point is better clarified by excising or debriding the wound rather than by attempting to probe it.

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days, the persistence of a spinal fluid block as demonstrated by lumbar puncture is indication for an exploratory laminectomy at the site of injury. Actually, persistence of such a block in a patient who does not show x-ray evidence of cord compression or unreduced deformity is very rare.

Definitive Treatment

Definitive care of spinal injuries is directed toward reduction of deformity and relief of cord compression followed by fixation in proper position until satisfactory healing has occurred. As already emphasized, this must be accomplished without further injury to neural tissue.

I. Simple fracture of a vertebral body without compression, or of any other part of a vertebra without displacement, with or without temporary neurological signs, is treated by immobilization in an appropriate plaster cast or brace for at least six to twelve weeks.

II. Compression fracture of one or more vertebral bodies is treated in general by hyperextension of the spine at the level of injury with prolonged fixation in this position.

(A) In the cervical region this is accomplished by traction and extension of the head with sufficient weight (usually from 12 to 15 pounds) until optimum position is reached, followed by continued traction with enough weight (usually from 3 to 5 pounds) to maintain this position for from eight to twelve weeks. The patient may then be transferred to an ambulatory type of plaster neck support or chin-occiput brace for another two to six months.

For prolonged cervical traction, the most effective and comfortable method is afforded by Crutchfield tongs. These are readily inserted under local anesthesia with the patient on a stretcher or bed. After shaving the scalp, two small drill holes are made through the outer table of the skull on either side of the vertex. The tong points are inserted and the lock-nut made secure. A rope is led from the tongs over a pulley projecting from the head of the bed. Countertraction is achieved by elevating the head of the bed on 12-inch blocks. The direction of traction may be altered by adjusting the position of the patient's head and the pulley as desired.

(B) In the thoracolumbar region, hyperextension at the level of injury is achieved by placing the patient on his back over a blanket roll or elevated section of the bed. Maintenance of the correct position is accomplished by application of a plaster body cast.

Forceful hyperextension may be necessary to achieve satisfactory position. It is carried out usually under heavy sedation or anesthesia by

1. suspending the patient face down on a hammock between two tables,
2. lifting the body from the floor with a broad sling at the site of injury, or
3. extension of the patient over a metal strip on an orthopedic table.

Nonpenetrating Wounds

Nonpenetrating wounds of the abdominal viscera encountered in civilian practice are commonly due to automobile and other transportation accidents, to industrial accidents, to riding and other activities associated with sports, and to various acts of violence.

The diagnosis of nonpenetrating injuries is far more difficult than that of penetrating injuries and failure to recognize visceral rupture is by no means uncommon. Delay or failure of diagnosis accounts in large measure for the consistently high mortality in this type of abdominal trauma.

Most of the symptoms and signs of intra-abdominal injury associated with nonpenetrating agents are of a general character and may give little precise information. A simple, severe contusion may cause shock, pain, tenderness, rigidity, and most of the symptoms and signs found in the actual bursting of viscera. Ileus occurs frequently after simple abdominal contusion. It becomes obvious, therefore, that the means of distinguishing contusion from actual visceral rupture are limited.

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those indications may be added absence of abdominal respiratory movements, and absence of peristaltic activity as determined by silence on auscultation. Roentgenographic demonstration of free gas under the diaphragm and the presence of blood in the vomitus or in the stool are further indications of intestinal injury. A progressive elevation in the leucocyte count and a rising temperature provide confirmatory evidence.

Diagnosis is often complicated by other injuries received at the same time, and the decision as to whether perforation exists is finally based on the total picture rather than upon any one indication.

As a practical approach to the subject it seems best to take up the common injuries to definite important viscera separately, recognizing of course that associated injuries of other structures may be present.

THORACO-ABDOMINAL WOUNDS

James M. Mason III, M.D., F.A.C.S., Birmingham

The term "thoraco-abdominal" is used to designate those wounds in which the pleural and peritoneal cavities and the diaphragm have all been transversed or otherwise injured, and is not applied to separate wounds of the thorax and of the abdomen. Although these wounds are discussed in the section on thoracic injuries, some additional comments are made here.

In many instances, the amount of pulmonary damage is relatively minimal and would not, in itself, warrant a thoracotomy. The necessity

The seriousness of thoraco-abdominal injuries may be considered in regard to the number of intra-abdominal viscera that are damaged. The anatomical position of the viscera allows for classification of the wounds as to the side of the body involved. When the wound is a perforating one, the trajectory of the missile may be projected by lining up the wound of entrance with the wound of exit and the organs involved may be fairly well predicted. When the injury is a penetrating one, the course of the missile cannot be so well visualized. Anteroposterior and lateral x-ray views of the chest and abdomen or stereoscopic views will be of great help in locating the position of retained foreign bodies and often by studying such x-ray films the course of the missile can be traced by flecks of opaque material left in its wake.

When the right diaphragm is traversed the liver is almost always injured. The liver often acts as a barrier preventing damage to other organs. However, when an intraperitoneal organ other than the liver is injured from the right side, it usually means that the liver has been traversed by a missile or transmitted force and serious damage has been inflicted, which is reflected in higher mortality in right-sided lesions.

In left-sided injuries more intra-abdominal organs are apt to be involved and from that viewpoint they may be considered more dangerous than right-sided ones. However, as pointed out above, abdominal visceral injury sustained from the right is usually more serious because of the associated damage to the liver.

Cardiorespiratory Physiology in Thoraco-abdominal Injuries

Although the general concepts of resuscitation of the injured apply equally as well to those with thoraco-abdominal wounds as to those with abdominal wounds, still the former group requires additional attention towards the disturbed or potentially disturbed cardiorespiratory equilibrium. This disturbance will, of course, be found in varying degrees. No routine can be adopted for all cases, but the surgeon should recognize the problems which this altered physiology presents and be ready to apply measures for correcting them.

Difficulties at times arise in the administration of intravenous fluids because of the potential dangers of overloading a circulatory system already embarrassed by direct pulmonary trauma, hemothorax, pneumothorax, or a combination of these. The damage within the peritoneal cavity, hemorrhage, or peritoneal contamination, may in themselves call for more vigorous and more rapid restoration of blood volume than the pulmonary system can tolerate. Often adequate blood volume can be obtained only after an impaired cardiorespiratory imbalance has been improved or corrected. This can at times be corrected preoperatively, but may not be accomplished without the intervention of surgery.

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Care of Skin

Special measures for skin care should be initiated as soon as the diagnosis of spinal cord injury has been established. In cord transections, pressure areas leading to ischemic necrosis develop with surprising rapidity. It is imperative from the beginning, therefore, to *change the position of the paralyzed parts at least every two hours.* The patient should be placed as soon as possible on a foam rubber or air mattress with great care to protect the sacrum, trochanters, malleoli and heels. If a Stryker frame is available and the patient's skeletal lesion permits its use, frequent changes of position are greatly facilitated.

The entire area of anesthetic skin should be lightly massaged with alcohol, dried carefully, and powdered at least once daily. The bed coverings should be kept dry at all times and as free as possible from wrinkles. After bowel movements or enemas, the perineum and sacral area should be thoroughly cleaned and dried. Frequent application of tincture of benzoin helps protect the skin in areas of pressure. If a decubitus lesion develops, it is imperative that the patient be kept off this region at all times.

Care of Bladder

Retention of urine develops at once after every severe cord injury and because of sensory paralysis may give rise to no discomfort. It is important, therefore, to insert a urethral catheter under aseptic precautions within a few hours after injury to prevent overdistention of the paralyzed bladder. Repeated catheterization should be avoided. A soft rubber catheter of the indwelling variety (size #16 or #18) should be used. If the bladder is already distended it should be decompressed slowly and then left on constant drainage.

As soon as possible a plan of tidal drainage which provides a closed system of automatic, periodic drainage and irrigation of the bladder, should be established. Several satisfactory methods have been devised. In the atonic bladder of acute spinal cord injury, the siphon curve usually should be placed only 1–3 centimeters above the level of the bladder; this position is then checked at intervals by cystometry. Further care of the bladder through the stages of rehabilitation and development of automaticity is not within the scope of this chapter.

Early suprapubic cystostomy for bladder drainage is indicated in patients with local injury, obstruction or infection obviating urethral drainage and under circumstances where installation of regulated, well-supervised tidal drainage must be unduly delayed.

Care of the Bowel

Paralytic ileus is a frequent early and distressing complication of all types of spinal injury and may necessitate use of prostigmine, pitressin,

if the left upper abdominal region or the left lower thoracic region is involved. Fracture of the left lower ribs is especially likely to be associated with injury to the spleen.

SYMPTOMS AND SIGNS OF THE SPLEEN INJURY. There is wide variation in the character and severity of symptoms and signs associated with injury to the spleen, depending upon the degree of injury and the amount of intraperitoneal hemorrhage, as well as upon associated injuries of the abdomen or elsewhere. In uncomplicated splenic injuries, clinical evidence is usually sufficient to permit making the diagnosis except in the relatively rare instances in which the injury is slight and in which bleeding has been only subcapsular.

There are usually subjective and objective evidences of shock and hemorrhage, as well as symptoms and signs due to free blood in the peritoneal cavity Abdominal pain, tenderness and rigidity, although usually diffuse, may be limited to the left upper abdominal quadrant and there is often limitation of abdominal respiratory movement. Flank dullness or even flank fullness, especially on the left side, may be detectable. Diffuse abdominal distention is not uncommon, especially in late cases in which there has been much intraperitoneal bleeding and associated ileus. A mass may occasionally be felt in the left upper abdominal quadrant. Bluish discoloration at the umbilicus is occasionally present.

CLINICAL LABORATORY STUDIES. Clinical laboratory studies, including hematocrit and blood volume determinations, are usually more useful as therapeutic guides than as diagnostic aids.

X-RAY STUDIES. Fluoroscopic and radiographic observations may reveal elevation or fixation of the diaphragm, displacement of the gastric bubble or fractures of the lower ribs, and may also demonstrate associated hemothorax or pneumothorax.

DIAGNOSTIC LAPAROTOMY. At times, due either to equivocal evidence of abdominal visceral injury or multiplicity of abdominal visceral injuries, a diagnosis of injury to the spleen cannot be made definitely by any other means than laparotomy.

Treatment of Injuries of the Spleen

SUPPORTIVE THERAPY BEFORE, DURING, AND AFTER OPERATION. The same general principles of supportive therapy which apply for patients who have undergone considerable blood loss and who are suffering from shock, apply in the management of patients with spleen injuries and should be instituted as soon as possible following injury.

The frequent association of thoracic injuries and the danger of respiratory tract infections require that attention be given to maintenance of an adequate airway, to correction of interference with normal respiratory function caused by pneumothorax, hemothorax,

if the peritoneal cavity is found filled with blood at operation the spleen should be among the viscera examined first. If injury is discovered during the rapid preliminary direct examination, splenectomy should be done as soon as possible, unless violent bleeding from some other site demands prior attention. The introduction of gauze or other material into or around an injured spleen for the purpose of temporarily controlling hemorrhage is, almost without exception, an unwarranted and futile procedure.

The impossibility of satisfactorily suturing even a minor wound of the spleen is so well known that there is little justification for even trying this method of treatment in any type of spleen injury. The availability of hemostatic agents, such as oxidized cellulose and gelatin foam, does not alter the need for splenectomy.

Rarely, there may be an injury of a splenic vein without injury of the spleen itself. Under such circumstances, the injured vein may be ligated, without removing the spleen.

The practice of ligating all blood vessels in the pedicle of the spleen without removing the spleen is not to be recommended.

The practice of ligating the splenic artery before ligating the splenic veins, commonly advocated and employed in connection with the elective removal of large diseased spleens, is of little or no value when removing an injured spleen

The administration of spleen constricting drugs immediately before ligating the splenic pedicle vessels, as a means of squeezing out blood from the spleen into the general circulation, has no application in the treatment of spleen injuries.

Repair of a wound of the diaphragm associated with injury of the spleen should be done for both immediate correction of disturbed respiratory function and for prevention of subsequent herniation of abdominal viscera into the thoracic cavity. This may require extension of the abdominal incision upward into the chest wall, as stated previously

If there is contamination of the peritoneum due to perforation of gastrointestinal viscera, drainage of the space from which the spleen has been removed, using rubber tissue drains brought out subcostally through a stab wound on the left side in the midaxillary line, is usually advisable as a possible means of preventing the development of a left-sided subdiaphragmatic abscess. Such drains also afford exit for blood not removed at the time of operation.

Postoperative Treatment. Postoperative treatment following splenectomy is the same as for other major abdominal operations associated with blood loss. From the standpoint of the splenic injury alone, there is no need for administration of antibiotic agents, but this type of therapy is often advisable because of accompanying injuries to other

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PRINCIPLES OF TREATMENT IN SEVERE FACIAL INJURIES

In few injuries is the final outcome so directly dependent on proper early care as in the treatment of a severe facial injury. The bony and cartilaginous frame-work of the face supports the soft tissues and teeth, and provides attachment for the muscles of expression and mastication. The character in the face, the emotional expression, and the function of chewing and eating depend upon a normal anatomical and functional relationship between these structures. Failure to restore displaced bone to its normal position or failure to resolve the puzzle of a jagged laceration of the eyelid, nose or mouth, may result in disfigurements which will permanently alter the appearance and function of the face. Only by early adequate reduction of all fractures and adequate splinting of the fragments before fixation of the bones has occurred, can the normal contours of the face be restored and only by accurate layer closure of the soft tissues will function be reestablished and scarring minimized.

The primary problems in the care of all severe injuries of the face are: (1) maintenance of an adequate airway, and (2) arrest of hemorrhage.

The airway may be obstructed by collapse of the mandibular arch which permits the unsupported tongue to fall back against the pharynx; it may be the result of crowding of the tongue by downward or backward displacement of the upper alveolar arch; or it may result from bleeding within the mouth. The tongue can be held forward away from the pharynx by turning the patient on his face, by traction on the tongue with a suture or a safety pin passed through it, or by traction on the displaced bone. Sometimes a McGill tube inserted into the pharynx may be better and more comfortable. Tracheotomy is seldom necessary.

Hemorrhage can usually be controlled by local pressure alone. Packing the open wound with sterile gauze may be necessary. Only if a large artery is torn or severed may immediate ligation be necessary. Shock must be treated appropriately in conjunction with the arrest of hemorrhage. Transfusion or other therapy should be begun promptly.

The next problems are (1) evaluation of the patient's general condition; and (2) evaluation of the extent of the local injury;

Brain damage, injuries of the chest or abdomen and major fractures must often take priority in treatment. The definitive facial repair

Prepared by Bradford Cannon, M.D., F.A.C.S., Boston, and sponsored by the American Board of Plastic Surgery.

the great variation in extent and character of liver wounds. Wounds caused by low velocity sharp objects, such as knives and bayonets, cause relatively little damage to liver tissue beyond the immediate area of the wound, whereas high velocity bullets and jagged shell fragments, as well as blunt forces, often cause damage far beyond the grossly apparent injury.

Wounds of the liver are of the following varieties: (1) contused wounds, with or without subcapsular hematomas; (2) guttered or furrowed surface wounds; (3) lacerated wounds, either linear or stellate; (4) penetrating and perforating wounds, with or without surrounding contusion; (5) macerated wounds; and (6) fragmented wounds.

From the standpoint of management and prognosis, hepatic injuries may be classified according to the degree of associated hemorrhage and shock, the severity of injuries to other parts of the body, and the amount of peritoneal contamination, as well as according to the extent of injury to liver tissue and major bile radicles.

Diagnosis of Injuries of the Liver. The possibility of injury to the liver must be suspected whenever there has been either a penetrating or a blunt injury to the lower chest or the upper abdomen, whenever there has been a fall or jump from a considerable height, and whenever the chest or abdomen has been subjected to either air or water blast.

Determination of the existence of injury to the liver by missiles can usually be accomplished by a careful study of the location and character of the wounds of entrance and exit, or by consideration of the wound of entrance in relation to the position of a retained missile as demonstrated by x-ray examination. In the instance of bullet wounds, a careful study of the wound of entrance in respect to the extent and distribution of skin contusion, and the extent and direction of subcutaneous undermining, will usually furnish helpful information concerning the course of the missile.

Symptoms of Injury to the Liver. The symptoms associated with liver injury may be so slight that the diagnosis is difficult. On the other hand, symptoms and signs may be so definite that its existence is quite apparent. The co-existence of injuries to other abdominal viscera increases the difficulty of determining the existence of, or the extent of, liver injury.

The location and degree of pain associated with hepatic injury are extremely variable, being related not only to the amount of bleeding from the liver and the amount of spillage of bile into the peritoneal cavity, but to the presence or absence of rib fractures and peritoneal irritation due to perforation of other abdominal viscera. Pain [illegible] be limited to the right upper quadrant of the abdomen, but it is [illegible] uncommonly diffuse on the right side or over the entire [illegible]

Hematocrit and blood volume determination are often of value in determining blood transfusion requirements.

Bile in the urine does not appear until several days have elapsed following injury, even after extravasation of large amounts of bile into the peritoneal cavity.

Roentgenologic examination following abdominal injuries is of particular value in the instance of retained missiles. Roentgenologic examination is also of value in demonstrating the existence and extent of thoracic injury which is so frequently associated. Fluoroscopic and radiographic examination may also be employed to demonstrate immobility or elevation of the diaphragm. Following operations roentgenologic examinations are of value in demonstrating the presence of the not uncommon complicating subphrenic and liver abscesses.

Peritoneal aspiration to determine the presence or absence of blood in the peritoneum is a valuable means of diagnosis of abdominal visceral injury. Introduction of a Potter needle through the lateral abdominal wall is a safe and very dependable measure.

When multivisceral abdominal injuries exist, it is often impossible to determine whether or not there has been injury to the liver. Under such circumstances definite determination of the existence or extent of liver injury must await exploration of the abdomen.

Preoperative Preparation

The principles of preoperative preparation for patients with injuries of the liver are quite similar to those which apply to all patients with abdominal visceral injuries. The blood loss usually associated with these injuries often demands even more blood replacement than is required by patients with other abdominal injuries. Antibiotic therapy should be instituted as soon as possible following injury both because of the liver damage itself and because of the frequent co-existence of gastrointestinal perforations.

Operative Treatment

The incision may vary somewhat, depending on the suspected location of the injury. In general, vertical right rectus or right paramedian incisions are preferable since they permit the extensions which are so often necessary to secure satisfactory access to other parts of the abdomen. Combined intra-abdominal and intrathoracic exposure also can be conveniently provided by upward extension of vertical abdominal incisions. Vertical abdominal incisions still further offer the advantage of permitting exteriorization of the colon in a most satisfactory manner if that should be necessary. For the exposure of the dome of the liver, a transthoracic-transdiaphragmatic approach furnishes the best exposure. In some instances it is advantageous to extend the

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Débridement should be minimal, in contrast to the recommended excisions of wounds elsewhere on the body. "It is better to save tissue which may die than to sacrifice any which may survive." The loss of even a small amount of skin about the eyelid or mouth may result in deformity. A piece of skin even though almost completely detached may survive as a free transplant if replaced in its normal position with loose sutures, minimal tension and a firm dressing.

MANAGEMENT OF FRACTURES

Fractures of the facial bones differ from most fractures because the displacement is due to the trauma itself and not to muscular pull. Consequently, the reduction of facial fractures depends on the restoration of the bones to their original position with sufficient fixation to maintain reduction against the minimal elasticity of the soft tissues and the pull of gravity.

Fractures of the mandible are exceptions to the above statement because the fragments are displaced by the very powerful muscles of mastication. In the reduction and fixation of mandibular fractures the pull of these muscles must be counteracted by appropriate fixation.

X-rays of the facial bones are important as a part of the patient's record and to confirm the clinical diagnosis. Proper posing of the head is essential for informative films. The outlines of the rim of the orbits, the zygomatic arches, the lateral and medial walls of the antra, the bony structures of the nose, the alveolar arches and the palate can be visualized in a vertical submental or Water's position. Fractures of the nasal bones are visualized in soft lateral views. Mandibular x-rays should include views of both sides of the jaw, the symphysis and both condyles Questionable fractures of the symphysis or condyles and the direction of fracture lines of the mandible will be revealed.

Reduction of fractures of the facial bones should be treated promptly unless there are urgent reasons for delay. The soft tissue swelling which accompanies a facial injury may mask an underlying fracture unless careful examination and x-ray studies are carried out. The swelling itself is not sufficient reason to delay reduction of the fracture. The facial bones usually solidify within two to three weeks, after which satisfactory reduction may be impossible.

The occlusion of the teeth and the palpable bony prominence of the face are the best guides to the accuracy of the reduction of face and jaw fractures. Simplicity is the essence in the treatment of all facial fractures, both for prompt and lasting relief of the patient's discomfort and for eliminating the need for constant adjustment of complicated appliances.

Most fractures of the mandible can be held in place by direct wiring of the teeth of the upper and lower jaws. An edentulous overriding

compression afforded by the abdominal and lower chest walls before the operative incision was made, or caused by removal or dislodgment of blood clots incident to exploration

In most instances, it is advisable to remove even those blood clots directly in the wound which, although temporarily serving a hemostatic purpose, are likely to become detached subsequently. It is usually better to assure more effectively against possible recurrence of bleeding by suturing the wound or introducing hemostatic agents, such as gelatin foam or oxidized cellulose held in place by means of sutures, than to depend on blood clots alone for hemostasis. When hemostatic agents are employed, they should be used in the smallest possible quantity, since their use in large amounts may contribute to the development of a liver abscess

Many methods, some quite ingenious, have been advocated for the control of bleeding from the liver. Hot moist gauze packs, as well as dry gauze packs, have been extensively employed as an expedient means of arresting bleeding from the liver. The injury to tissue caused by excessively hot moist packs makes their use undesirable. The frequent occurrence of active bleeding at the time of removal of gauze packs left in place at the completion of operation, and the high incidence of abscesses of the liver when gauze packs are so employed, have furnished convincing evidence that this is not a good practice. Under no circumstances should iodoform gauze packs be used, because of the danger of iodoform poisoning.

Violent bleeding from the liver may be arrested temporarily by digital compression of the hepatic artery and the portal vein by passing the index finger through the foramen of Winslow and making counterpressure with the thumb This may be a lifesaving procedure.

The use of actual cautery for the control of liver bleeding is to be avoided.

Removal of Foreign Bodies from the Liver. The presence of single or multiple missiles superficially or deep in the liver substance presents a serious problem Readily accessible foreign bodies which can be lifted out easily without considerable tearing should be removed. Multiple small missiles which may have been visualized by x-ray examination but which cannot be easily seen or readily felt, and which cannot be removed without inflicting considerable additional damage, should be left in place.

Removal of Loose Fragments of Liver, Blood and Foreign Bodies from Peritoneal Cavity. Fragments of liver tissue lying free in the abdominal cavity or portions of the liver which are attached by inadequate pedicles should be removed. Under certain circumstances, contused portions of the liver, particularly portions of the free edge, are best excised. Such excision is likely to be associated with

because, as soon as the pack is removed, the drainage tract tends to close prematurely despite attempts to substitute rubber tissue drains for the pack. In order to reinstitute adequate drainage, it is necessary to reopen the abdomen and to introduce drains under direct vision.

Perforation of the diaphragm, even though repaired, predisposes to the development of bile empyema or a biliary thoracic fistula. This is especially true if bile and other fluid in the peritoneal cavity resulting from liver injury cannot drain externally, either because of the presence of a pack or for other reasons.

INJURIES TO THE GALLBLADDER AND BILE DUCTS

Ambrose H. Storck, M.D., F.A.C.S., New Orleans

The mortality associated with injury to the extrahepatic biliary tract is high, not only because of the frequently associated injury to major blood vessels which may be responsible for death even before patients can reach a hospital, but because of the serious nature of associated injuries present even in those patients who live long enough to be hospitalized. Wounds about the hilum of the liver also are likely to involve such structures as the duodenum, the pancreas, the stomach, and the colon. Obscuring hematomas involving the hepatoduodenal omentum, and the retroperitoneal space in the region of the head of the pancreas and the first and second portions of the duodenum, are frequently present and make definite identification of injuries to the bile ducts difficult. Extensive destruction of the extrahepatic bile ducts makes satisfactory repair of the injury either difficult or impossible.

The character and extent of injury to the gallbladder vary greatly. There may be a single perforation, multiple perforations, lacerations, or partial avulsion of the gallbladder from its bed. Injuries of the extrahepatic bile ducts likewise differ greatly in extent, varying from small lacerated wounds to extensive destruction of the ducts.

Injuries to the extrahepatic biliary system are almost invariably associated with injuries to the liver. There are no distinctive signs or symptoms of injury to the gallbladder and bile ducts.

Treatment of Injuries to the Gallbladder

The general plan of management of injuries to the extrahepatic biliary ducts is essentially the same as for injuries to the liver. Depending on the location and extent of injury to the gallbladder, the most appropriate treatment may be cholecystostomy with purse-string closure of perforations or suture of a laceration or cholecystectomy. Whenever closure of a wound of the gallbladder is done, cholecystostomy should be performed. If the injury is in the region of the fundus of the gallbladder, cholecystostomy may be performed through the site of injury.

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bones from the skull. Support by some type of dental appliance is usually necessary in conjunction with prompt reduction of other bony displacements associated with these fractures. Before union of the bones of the face has become too firm, normal dental occlusion must be restored. Elastic traction between upper and lower teeth by the third week after injury will draw the dental arches together.

MANAGEMENT OF THE SOFT PARTS

All fresh lacerations of the face should be repaired promptly. The healing power of the face is excellent and the resistance to infection high. Success depends on observing certain precautions, the most important of which is to do no additional damage. This includes no unnecessary debridement, no wide sutures which will leave stitch marks, and no excessive tension, especially on flaps of skin with precarious blood supply. All wounds must be thoroughly cleansed, foreign material removed and hematomas evacuated. Closure of the subcutaneous tissues as well as the skin must be done with very fine suture material and all skin sutures should be removed within 48 to 72 hours.

Great care and patience are necessary in replacing the jagged edges of torn and avulsed skin of the eyelids, nose and mouth, especially if the laceration extends through both surfaces of the part with a full-thickness separation of the edges. The fitting together of obscurely misplaced flaps may require several attempts before the correct position is secured. Obvious points of approximation such as the vermilion border, the eyelid margin or the alar margin, are useful as starting points for suturing.

Sutures on the inner surface of the mouth, nose or eyelid should be only enough to secure accurate apposition of the mucosa. Puncture wounds, especially of the lips, are best left unsutured. Free drainage is thus maintained and the likelihood of infection minimized. Small lacerations on the face can sometimes be approximated by adhesive support alone. This method is often preferable in children because anesthesia, sutures, etc. are then unnecessary.

Skin losses can be replaced by a skin graft if the deep tissues are not severely damaged In extensive full thickness losses of the cheek, nose and rarely the eyelid, mucosa and skin may be approximated to close the raw surface in anticipation of later repair.

Suture of branches of the seventh nerve in the face is impractical because the fibers are tiny and identification difficult. If the larger trunks near the angle of the jaw can be identified, suture is indicated. Primary repair of a lacerated Stenson's duct should be considered in injuries of the cheek, but it may have to be postponed.

That secondary revisions of the soft tissues may be necessary in many severe facial injuries must be anticipated in the management of the

extrahepatic bile ducts, placement and fixation of omentum over t *site of repair should always be done, and, whenever possible, pe*-tonealization of the area of repair should also be accomplished, pr vided this does not result in constriction or angulation of the bile du

Treatment of Injuries to Retroduodenal Portion of Common Bile Duct

Because of the relatively inaccessible position of the retroduoder portion of the common bile duct and because of the obscuration r sulting from tissue damage and the hematoma, usually present, iden fication and repair of injuries are difficult. Such injuries, often ov looked at the time of operation, are likely to contribute to a fa outcome, and are frequently found only at autopsy. Whenever t existence of injury to this portion of the common bile duct is suspecte it should be exposed by mobilizing and reflecting the overlying du denum medially and downward. Satisfactory repair is likely to impossible An expedient procedure is to span the defect by means a catheter or a T-tube introduced through the supraduodenal porti of the common bile duct and from there into the duodenum. Id for this purpose is the type of T-tube which has one long limb. Un some circumstances, even this may not be feasible, and it may necessary to ligate the supraduodenal portion of the common b duct and to perform a cholecystoduodenostomy or other type cholecystenterostomy.

If injury in the region of the retroduodenal portion of the comm bile duct is so extensive that any attempt at repair or even identific tion of this portion of the biliary tract is impossible, the only availal procedure may be to dispense with mobilization of the duodenum, ligate the supraduodenal portion of the common bile duct, and perform whatever type cholecystenterostomy is feasible.

It is always desirable, when possible, to re-establish the continui of the bile ducts When this is either impossible, or would be too ti consuming in view of the patient's condition, the establishment external biliary drainage, with the least amount of other surgic intervention, is the safest procedure

Drainage of Peritoneal Cavity Following Injuries to Gallbladder and Extrahepatic Bile Ducts

Because of the frequently associated injury to the liver, duoden and pancreas, as well as the danger of bile leakage even from sat factorily repaired bile ducts, drainage of the subhepatic space as w as the other spaces commonly drained in patients with liver injur should be performed whenever there has been injury to the gallbladd or extrahepatic bile ducts

CLOSED INJURIES. Injury of the abdominal viscera from blunt traum predominates in civilian life, whereas in warfare penetrating wound frequently mutiple from high-explosive missiles, comprise the bulk abdominal casualties. Blunt trauma is much more likely to ruptu solid organs—the kidney, liver and spleen in order of frequency whereas the target area becomes the paramount factor in penetrati and perforating trauma. Consequently, in the latter types of inju the small intestine comes first in frequency of injury.

The injuries to the upper gastrointestinal tract from blunt force ca be ascribed to three mechanisms: first, compression between the a terior abdominal wall and a bony prominence; secondly, tangenti pull on the abdominal wall transmitted as a tearing force against tl gastrointestinal tract and its mesentery at fixed points; and thirdl the bursting or explosive force of rising hydraulic pressure. The l mechanism is well illustrated by underwater blast. Perforation of ileu or colon may be seen as the only abdominal injury under the circumstances.

PENETRATING AND PERFORATING INJURIES. Owing to its relative large volume, the upper gastrointestinal tract is often injured by hi explosive missiles and various pointed weapons wielded by hand. the case of bullet, mine, grenade, or shell fragment wounds the dama to the stomach, duodenum, or small intestine is often extensive a multiple lesions may be present. The wound of entrance may treacherously remote from the abdomen—even in the thighs or thor Damage to the mesentery may be such as to require resection of int tine even though the intestinal wound itself might be dealt with suture closure. There is often hemorrhage, gross contamination of t peritoneal cavity and shock. These have been among the most let wounds seen at the forward hospital units in the last two World Wa Both in civilian and military surgery, however, remarkable impro ments in the care of these patients have attended the advances anesthesia, preoperative and postoperative care, and proper use blood transfusion and antibiotic drugs.

Clinical Management

With rupture or perforation of stomach, duodenum, or small i testine there may be hemorrhage, spreading peritoneal irritation, a shock. The usual signs, therefore, are abdominal tenderness and spa which may at first be localized, rising pulse rate, leukocytosis, naus and vomiting, and reduction in audible peristaltic sounds. There m be evidence of free air under the diaphragm as shown by the a dominal scout film, and the patient may complain of the shoul pain characteristic of phrenic irritation. Shifting dullness, declini red cell count, and rapidly falling blood pressure may indicate t

Closed Injuries. Injury of the abdominal viscera from blunt traum predominates in civilian life, whereas in warfare penetrating wound frequently mutiple from high-explosive missiles, comprise the bulk abdominal casualties. Blunt trauma is much more likely to ruptu solid organs—the kidney, liver and spleen in order of frequency whereas the target area becomes the paramount factor in penetrati and perforating trauma. Consequently, in the latter types of injur the small intestine comes first in frequency of injury.

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Penetrating and Perforating Injuries. Owing to its relative large volume, the upper gastrointestinal tract is often injured by hi explosive missiles and various pointed weapons wielded by hand. the case of bullet, mine, grenade, or shell fragment wounds the dama to the stomach, duodenum, or small intestine is often extensive a multiple lesions may be present. The wound of entrance may treacherously remote from the abdomen—even in the thighs or thor Damage to the mesentery may be such as to require resection of int tine even though the intestinal wound itself might be dealt with suture closure. There is often hemorrhage, gross contamination of t peritoneal cavity and shock. These have been among the most leth wounds seen at the forward hospital units in the last two World Wa Both in civilian and military surgery, however, remarkable impro ments in the care of these patients have attended the advances anesthesia, preoperative and postoperative care, and proper use blood transfusion and antibiotic drugs.

Clinical Management

With rupture or perforation of stomach, duodenum, or small i testine there may be hemorrhage, spreading peritoneal irritation, a shock. The usual signs, therefore, are abdominal tenderness and spa which may at first be localized, rising pulse rate, leukocytosis, naus and vomiting, and reduction in audible peristaltic sounds. There m be evidence of free air under the diaphragm as shown by the a dominal scout film, and the patient may complain of the shoulc pain characteristic of phrenic irritation. Shifting dullness, declini red cell count, and rapidly falling blood pressure may indicate t

INITIAL TREATMENT OF ACUTE INJURIES OF THE EYE

INJURIES OF THE EYE constitute a form of trauma which demands highly specialized care. It is not, unfortunately, a type which permits definitive care by other than trained personnel, even by surgeons who are highly competent in their own specialized fields. The structure of the eye is so detailed, and the surgery required so extremely delicate and so full of potentialities for further damage, that physicians whose acquaintance with ophthalmology is limited, as it usually is, to the general courses given in medical school would seldom wish to cope with it. Furthermore, complete examination of the eye, which is necessary before definitive surgery can be attempted, requires specialized equipment which is not likely to be generally available and with the use of which the non-ophthalmologist would not be acquainted even if he had it at his disposal. The same holds for the very delicate instruments and equipment used in ophthalmic surgery.

On the other hand, if a disaster of magnitude among the civilian population is to be prepared for, as it seems that it must be, civilian methods of ophthalmic practice must be modified to suit the emergency. Ophthalmologists would not be available in sufficient numbers to handle all casualties, nor would the circumstances be auspicious for prompt definitive surgery if they were. It would thus be necessary for general surgeons to be responsible for the initial care of ocular injuries. It would, in fact, be economical of time and personnel if they were to add this responsibility to their responsibility for the care of other injuries, with which, in many instances, ocular injuries are likely to be associated. Many times, indeed, the ocular injuries will be overshadowed by associated injuries which may offer a far greater danger to life.

This chapter has, therefore, been prepared on the realistic assumption that in the event of wartime disasters among the civilian population, the care of ophthalmic casualties would be organized on the same principles as those on which their care was based in World War II: that is, surgeons without special training in injuries of the eye would render first aid and apply other measures designed to counteract the effects of initial trauma, prevent further trauma, and keep the casualty in the status quo, or render him transportable until his care could be assumed by a qualified ophthalmologist.

Prepared by William B Clark, M.D., F.A.C.S., New Orleans, Editor, Edwin B. Dunphy, M.D., F.A.C.S., Boston, S Rodman Irvine, M.D., F.A.C.S., Beverly Hills, Lawrence T. Post, M.D., F.A.C.S., St Louis, and Derrick T Vail, M.D., F.A.C.S., Chicago. At the time this chapter was written the foregoing composed the American College of Surgeons' Advisory Council on Ophthalmology, of which Dr. Vail was chairman.

4. Use of median vertical incision for exploration when there are no specific leads as to site of visceral injury.
5. Complete and gentle examination of all the organs which may have been damaged.
6. Avoidance of exteriorization of small intestine, but instead using suture or resection.
7. Postoperative use of antibiotics, nasogastric suction and early ambulation.

INJURIES TO THE COLON AND RECTUM

William F. MacFee, M.D., F.A.C.S., New York

Penetrating or perforating wounds of the colon and intraperitoneal portion of the rectum are usually indistinguishable clinically from similar injuries to other parts of the digestive tract. Diagnostic efforts, therefore, are directed more toward determining whether a perforation exists in the gastrointestinal tract than toward establishing its exact location.

If the colon or rectum has been penetrated, the early symptoms and signs are more or less nonspecific. However, the presence of fresh blood in the rectum, or the passage of bright red blood per rectum suggests injury to the colon or to the rectum, or both. If the injury involves the extraperitoneal portions of the colon or rectum, hemorrhage may give rise to a retroperitoneal hematoma which often is painful. Roentgenograms may reveal the presence of gas in the retroperitoneal spaces. At operation, bluish discoloration of the posterior parietal peritoneum and tumefaction indicate retroperitoneal injury, and possible involvement of the colon or rectum must be considered. It is to be remembered that blood extravasated in the retroperitoneal space diffuses easily through the loose areolar tissue of that area, and the point of injury to the colon or rectum may be far removed from the most obvious hemorrhagic area.

When doubt exists as to whether a penetrating wound involves the peritoneal cavity it is permissible to excise the wound tract down to the peritoneum in order to determine this important point. This procedure applies particularly to wounds in which the agent has entered the abdomen from the side or back, but is valuable as a diagnostic procedure in any wound which may have entered the peritoneal cavity. If by chance the missile has entered the colon, rectum, or other viscus through its retroperitoneal aspect, the perforation may be revealed by wound excision, whereas it might be overlooked from an intraperitoneal approach.

When it appears relatively certain that intra-abdominal injury exists, the abdominal incision should not be made until the site of injury has been localized as accurately as possible. It should then be placed where it will provide the best approach to the involved

Exteriorization of perforations or lacerations of the descending colon may be a difficult procedure, particularly so if the perforation is not suspected before operation and if the incision is not properly placed for adequate exposure. In order to perform a colostomy in this region it is necessary to incise the parietal peritoneum along the lateral margin of the colon and do considerable dissection before it is possible to bring a loop out through the abdominal wall. Occasionally, when the patient is in poor condition, it may be preferable to close the perforations and do a proximal diverting colostomy in the transverse colon.

SIGMOID COLON. The sigmoid colon, as a rule, leads itself readily to exteriorization For this reason, and because of the heavy contamination of its contents, exteriorization is the treatment of choice for nearly all perforations of the sigmoid. If an unusually short mesentery or a thick abdominal wall makes colostomy impracticable, suture of the perforation with a diverting colostomy at a higher level may be done.

Wounds of the Rectum

Injuries of the rectum, like those of the colon and other abdominal viscera, are divided into penetrating and nonpenetrating types and are produced in the manner already described for abdominal injuries in general Penetrating wounds of the rectum are further classified as intraperitoneal or extraperitoneal according to the location of the injury.

PENETRATING WOUNDS Frequently, injury of the rectum may result from penetrating wounds of the buttocks and other pelvic structures or from wounds of more remote regions such as the thighs and abdomen and may be associated with fractures of the pelvic bones.

Penetrating or perforating injuries may occur also as the result of impalement through the perineum or anus, or through the accidental or intentional introduction of foreign materials of various kinds through the anus.

The rectum has also been perforated on numerous occasions as the result of proctoscopy and other diagnostic and therapeutic procedures, and instances of accidental injury during various pelvic operations are not lacking.

The diagnosis of the penetrating variety of injury to the rectum is relatively easy if the condition is suspected, and if the lesion is below the level of the pelvic floor.

Intraperitoneal perforations are associated with suprapubic pain and tenderness and present much the same general and localized findings seen in perforations of the large intestine at a higher level. The presence of fresh blood in the rectum is presumptive evidence of injury to the

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ment from the outset. Incorrect treatment, or undue delay in the application of the proper treatment, may lead to a disastrous outcome in a case in which such an outcome was not originally inevitable. The circumstances of a civilian mass disaster, like the circumstances of warfare, may not always permit ideal ophthalmic care, but the casualty's chances will be greatly improved if an ideal routine of management is planned and is adhered to as closely as possible.

PRINCIPLES OF MANAGEMENT

One of the extremely important ophthalmic lessons learned in World War II should be borne in mind in the event of a civilian disaster in any future war. This lesson is the safety of delay in the management of injuries of the eye, particularly in the management of intraocular foreign bodies, which are present in half or more of all such injuries.

In World War II ophthalmologists were not attached to forward hospitals. Their work was done in hospitals to the rear. Army directives forbade definitive treatment in injuries of the eye until the casualty reached an installation equipped and staffed to render definitive care. The first-aid men who brought the casualty off the battlefield were taught that their task was to get him to a medical officer as promptly as possible. In the meantime, all that they were allowed to do was to remove superficial dirt and debris as gently as possible; cover the eye with sterile pads; instruct the casualty to keep as quiet as possible and under no circumstances to touch his eyes, and then arrange for his evacuation, preferably recumbent, to an evacuation hospital. When the casualty reached this forward hospital, all that the general surgeon who cared for him was permitted to do was to make a diagnosis and to apply such other emergency treatment and measures as were necessary to make him transportable farther to the rear. His definitive care was the business of the ophthalmic surgeon in the base hospital. The responsibility of the surgeon in the forward hospital ended when he had carried out the simple measures just mentioned. His instructions included the admonition to do no more.

The initial care of mass ophthalmic casualties in a civilian disaster should be based upon these bluntly stated principles. General surgeons, for practical reasons, must assume the immediate care of most of these casualties but they should stop at that point. Manuals of first-aid, and even some texts on ophthalmology, describe more or less complicated procedures to be carried out by nurses and even by first-aid workers. They should all be forgotten. The keynote of the early care of ocular injuries by nonophthalmic personnel should be, again to state it bluntly, to limit treatment to absolutely essential first aid and adjunct measures and thereafter to refrain from doing harm.

Establishment of a diverting proximal colostomy is an essential part of the treatment of extraperitoneal wounds of the rectum, the sigmoid colon being the site most often selected. It is important that the diversion of the fecal stream be complete.

The striking improvement in the results of treatment of wounds of the rectum in World War II as compared with World War I is due principally to 1. Thorough débridement of the wound; 2. Establishment of adequate drainage of the perirectal space; 3. Proximal colostomy with complete diversion of feces; and 4. Use of antibiotics.

Foreign Bodies in the Rectum

Discussion of injuries of the rectum should not be closed without mention of foreign bodies in the rectum. Surgeons have been called upon to remove a great variety of foreign material from the rectum which had been introduced for a variety of reasons. Removal is invariably more difficult than introduction. Relatively soft materials such as fruits and vegetables can sometimes be removed by the use of suitable grasping forceps or a corkscrew. Foreign bodies consisting of metals or glass may prove extremely difficult, and occasionally it becomes necessary to open the rectum posteriorly, or even intraperitoneally, before removal can be accomplished.

The management of wounds produced in this manner calls for judgment in the individual case. Whether the rectum can be closed without proximal colostomy will depend largely upon the condition of the rectal wall at the time of operation. If the foreign body is large and has been present for many hours, the distended portion of the rectum may be in such condition that closure without proximal colostomy would be hazardous.

Wounds of the Mesentery

The seriousness of wounds of the mesentery depends upon the extent of injuries to the mesenteric blood vessels. If only a few of the smaller vessels are severed, sufficient blood supply may remain to maintain the nutrition of the corresponding segment of intestine. If major vessels are involved, the dependent segment may rapidly become blue, atonic, and gangrenous. If at the time of operation there is doubt as to the viability of the intestine, the administration of pure oxygen by the anesthetist will cause a brighter red color to appear in the viable portions of gut. The demonstration of peristaltic activity in a segment in response to stimulation with warm gauze pads provides further evidence of viability.

If it is clear that a segment of bowel is devitalized, or if doubts concerning its viability cannot be removed, the segment should be exteriorized if it is large bowel. If exteriorization cannot be readily

more frequently after operations for traumatic conditions than after operations performed under ordinary conditions.

The closure most resistant to disruption is made with all-inclusive *retention sutures of silkworm gut or wire which can be removed when* healing is complete. After the retention sutures have been placed, the various layers of the wound should be closed with interrupted *sutures of chromic catgut.* The layer of subcutaneous fat should not be sutured. Silk or cotton is suitable for the skin.

Postoperative Treatment

Gastrointestinal intubation by means of a Miller-Abbott type of tube should be carried out in all but the simple cases. Suitable antibiotics should be started at once. Body fluid requirements should be met by the use of parenteral glucose solution, five per cent, in amounts of about 3000 cc. per day. If there is vomiting, half of the glucose should be given in physiologic saline solution.

Specific deficiencies, such as blood, or constituents of the blood or plasma, should be compensated by appropriate therapy.

Food by mouth should be given only when there has been a resumption of gastrointestinal peristaltic activity. Attempts to hasten the return of peristalsis by the use of drugs usually are fruitless and may be harmful. Enemas likewise are ineffective until peristaltic activity has returned If given, they should consist of plain tap water which is readily absorbed if not expelled.

Ambulation should be determined by the patient's condition rather than the number of days since operation.

Complications should be anticipated and a serious attempt made to recognize them promptly. The possibility of undiscovered perforations or other injuries should be kept in mind. The possibility of foreign bodies having been left in the wound should also be remembered. Focal necrosis of bowel wall due to contusion or devascularization may cause delayed perforation

Urinary retention and fecal impaction are common complications

The outcome following perforation or rupture of the colon or rectum depends in great measure upon attention to detail at the operating table and competent supportive treatment afterward.

INJURIES TO THE PANCREAS

Charles B. Puestow, M.D., F.A.C.S., Chicago

Early Care

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EXAMINATION

Whether under the circumstances of a civilian military disaster it would be possible to examine the patient's eyes in the ordinary sense of the term, is highly doubtful. The following routine should be observed, however, if it is at all practical.

The examination is best made in a partially darkened room, with a good source of artificial light, such as would be supplied by a gooseneck standing lamp with a 75 to 100 watt frosted bulb. If necessary, examination can be made by daylight. A headlamp is desirable, but a pencil flashlight supplies sufficient illumination for practical purposes. The patient faces the light but is out of its direct rays.

For a detailed examination of the eyeball, the use of some instrument which will magnify the ocular structures by at least two to two and one-half diameters is necessary; the eye is so small that the component parts cannot otherwise be properly identified. If the physician making the examination has available, or knows how to use, a loupe or an ophthalmoscope, that is naturally desirable though it is not particularly likely. Details of the cornea can be made out by a condensing lens supplemented by a beam of light thrown onto the eye while the patient changes his direction of gaze.

Injuries of the eye should be suspected in all head injuries. They should also be suspected in all unconscious patients. Both eyes should always be investigated, even if the history and the gross findings indicate only unilateral injury.

If the patient has other injuries, he must be examined lying down. If he is able to sit up, a more satisfactory examination can be made, particularly if a chair with an adjustable head rest is available.

All movements should be extremely gentle on the part of the physician and the patient should be warned against sudden changes of position. The chances of intra-ocular hemorrhage and loss of vitreous, which are risks in all ocular injuries, can be increased by movement on the part of the patient and carelessness on the part of those attending him. Pressure on a damaged eyeball is extremely dangerous and should be avoided. Probing should never be attempted.

If lid spasm is so great that proper examination is impossible, it may be necessary to instill a local analgesic such as pontocaine (one-half per cent solution) to secure it. The lids are gently separated, spasm being overcome by the use of lid hooks if they are available, or by carefully placed retraction sutures if hooks are not available. Military ophthalmologists have found that sodium pentothal anesthesia is an excellent means of securing relaxation. It is doubtful that a surgeon whose only duty is first aid would be justified in resorting to pentothal, and it is definitely not safe in young children or in elderly persons.

such an exploration, the pancreas should be examined. If the capsule is *not ruptured, even though minimal subcapsular hemorrhages exist,* the organ should not be incised nor should drains be placed in its proximity because of the danger of subsequent pancreatic fistulas. If the pancreas is ruptured and is bleeding, hemorrhage should be controlled by adequate ligation and suture, and an attempt should be made to oversew the organ. Devitalized areas of the pancreas occasionally can be removed if such surgery will not interrupt the continuity of the main pancreatic ducts.

When an injury transects the pancreas, an effort should be made to re-establish the continuity of any ruptured main pancreatic ducts, especially if division has occurred near the head of the organ. The ends of the ducts should be anastomosed with fine interrupted sutures, following which an effort should be made to close the capsule of the gland. If the transection occurs to the left of the spine, it may be advisable to remove the tail of the pancreas and to oversew the proximal end of the gland to minimize leakage of pancreatic secretions. When this is done, it usually is necessary to remove the spleen at the same time. When such injuries are found, the abdominal cavity should be drained. Trauma to the pancreas may be followed by pancreatic cysts, abscesses or fistulas.

transfusions should be given and the degree of renal injury determined by pyelography. If this shows no great deviation from normal, it is still advisable to refrain from operation and trust to rest and further transfusion, since most of such patients will recover. A few may require operation later because of perinephric abscess, cyst, or hydronephrosis.

When the pyelogram reveals that the kidney is blasted beyond recognition and especially if signs of progressive hemorrhage are evident, prompt nephrectomy is indicated, provided the patient's general condition will permit. Experience has shown that nephrectomy in the presence of severe shock is very often fatal. In gunshot wounds with concomitant bowel perforation the whole attention should be given to the bowel and no attempt made to repair or remove the kidney unless the patient is an excellent surgical risk.

In summary, it is safe to say, first, that the general majority will recover without operation, but there is a small group in which the kidney has been irreparably damaged and must be removed; second, operation on the kidney during shock is absolutely contraindicated; and, third, retrograde pyelograms give essential information often not obtained from excretory pyelograms.

INJURIES TO THE BLADDER

Except for the penetrating wounds of warfare and the occasional accidents of pelvic and transurethral surgery, rupture of the urinary bladder almost always occurs as a complication of fracture of the bony pelvis. Fully 95 per cent of bladder ruptures encountered in civilian practice are from this cause. Indeed the coincidence is so classical that in every case of pelvic fracture bladder rupture should be suspected and immediate examination carried out lest it be overlooked and hours of serious urinary extravasation occur before it is discovered.

With the pubic arch or one of the pubic rami splintered, a spicule of bone cuts or pierces the front bladder wall. Accumulated urine within the bladder flows out into the loose areolar tissue of the space of Retzius from tonic bladder contraction and, thereafter, that which is excreted continues to extravasate. After only a few hours of this leakage, extensive extraperitoneal extravasation of the pelvic cavity occurs with severe phlegmonous destruction of the infiltrated tissues and extreme general toxemia from local absorption. In those rare instances in which the bladder fundus is ruptured, the leakage is intraperitoneal and, surprisingly enough, far better tolerated than when the perivesicular structures are infiltrated.

The symptoms of bladder injury are often obscure until such time as extensive extravasation has occurred. Unless bladder injury is suspected the deep pubic distress can easily be mistaken for the pain of the pelvic fracture. Occasionally persistent bladder spasm occurs with so-called

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3. Injuries of the conjunctiva alone are infrequent because its loose attachment gives it a degree of elasticity which permits it to slide and stretch before the impact of the wounding agent.

4. Double vision suggests injury to the extraocular muscles or to their nerve supply.

5. Emphysema of the orbital tissues indicates an associated fracture extending into the paranasal sinuses.

6. Enophthalmos suggests a fracture of the roof of the maxillary sinus or orbital floor, with sinking of the orbital contents.

7. The presence of a laceration is presumptive evidence that a foreign body has entered the eye. Prolapse of any portion of the uveal tract or of the vitreous similarly indicates a perforating injury and a possible intra-ocular foreign body.

8. Prolapse of pigmented uveal tissue or of vitreous in a wound of the sclera is diagnosed by the presence of a bead of stringy, viscid material, like the white of an egg. A shallow anterior chamber indicates that aqueous has escaped through a corneal or limbal wound.

9. Loss of vision is complete if there is severe intra-ocular hemorrhage, which will so obscure the retina that none of its details can be visualized. Loss of vision may also indicate injury to the optic nerve, as the result of contusion, concussion, or complete severance. Damage to the optic nerve or hemorrhage into its sheath is often suggestive of a fracture through the apex of the orbit.

Even if the surgeon who is treating the casualty is unaware of the significance of these various findings, he should make careful note of them on whatever record form is provided, as they will be of great significance to the ophthalmologist who will later see the patient.

FIRST-AID MEASURES AND ADJUNCT THERAPY

First-aid measures, as already emphasized, should be limited to those which are absolutely necessary. The eye is gently irrigated with physiologic salt solution or boric acid solution, which will carry away much of the foreign material and debris introduced by the injury. Whatever is left and is not embedded can be removed by the gentle application of a wisp of cotton or perhaps by small forceps. These remarks apply only to superficial foreign bodies. Those within the eye or embedded in the cornea should be left untouched.

If the patient is unconscious and cannot close his own eyelids, they may be closed by placing sutures through the skin and subcutaneous tissues of the upper and lower lids, next to the lash edge, and tying them together. A simpler method is to place a suture through the skin of the upper lid, draw the eyelid down, and anchor the free ends to the cheek with adhesive If the upper lid is missing, the process is reversed.

The protection of the damaged portion of the eye by conjunctival

INJURIES TO THE MALE URETHRA

Injuries of the male urethra require early recognition and prompt treatment. The immediate danger is shock and extravasation. Minor injuries may heal spontaneously while severe injuries are surgical emergencies. They may be divided into two groups: (1) anterior urethra, which includes the bulbous portion, commonly involved in straddle injuries, and (2) posterior urethra, more often involved in fractures of the bony pelvis.

Symptoms and Diagnosis. (1) Blood at the meatus is the earliest and most common sign. (2) Retention of urine occurs in severe injury. (3) The swelling of urinary extravasation may be seen in the perineum, scrotum, or lower abdomen if the patient has urinated. (4) Rectal examination is valuable in posterior urethral injury. In complete rupture the prostate is rendered movable and dislocated upward. (5) Catheterization is imperative to determine the degree of injury but must be done with utmost gentleness and strict asepsis.

Treatment. If catheterization is possible, a Foley bag catheter should be left indwelling to prevent voiding with the danger of extravasation. (If clear urine in quantity is obtained, there is assurance that injury of the bladder has not occurred.)

If a catheter will not pass, it is evidence that complete rupture has occurred. Two problems at once present themselves: first, extravasation of urine and, second, re-establishing continuity of the urethra. Fortunately an asthenic retention often occurs and the patient is seen before he has extravasated his torn tissues by voiding. In such an event immediate cystostomy must be done. If delay is unavoidable, suprapubic trocar puncture is justified.

If the patient has already extravasated his tissues by voiding, immediate cystostomy still is indicated to avoid further extravasation. At the same time, wide incision and drainage of the extravasated areas must be done to prevent massive tissue sloughing and infection.

With the bladder open a sound can be passed from within outward to meet a second sound passed into the urethra. Holding metal on metal the outer sound can be guided past the fault in the urethra and advanced into the bladder. The heel of an ordinary catheter may then be pushed tightly onto the tip of the sound and drawn back out of the urethra. The tip of a Foley bag catheter may then be stitched to the plain catheter and drawn into the bladder and inflated. It is left indwelling two or three weeks as a splint over which the urethra will bridge and heal. It also offers perfect bladder drainage so that the cystostomy drain can be removed in a few days and the wound allowed to heal.

Injury of the female urethra is uncommon. A catheter can usually be

INJURIES TO THE SOFT TISSUES OF THE EXTREMITIES

INJURIES TO THE SOFT TISSUES of the extremities fall into one or more of the following categories: contusions, abrasions, penetrating wounds, lacerations, avulsions, and ruptures. Any combination may exist. Do not be satisfied with the obvious. A minor contusion, indicating nothing more than a point of impact, may be accompanied by a serious distant lesion.

FIRST AID

Protect the extremity against progressive or secondary damage until the diagnosis is made and treatment carried out. Except in obviously minor or superficial injuries, splint the lower extremity or support the upper extremity by a sling and swathe. Wounds should be covered with a clean, dry dressing without cleansing, removal of foreign material, or application of antiseptics. Hemorrhage, unless massive, should be controlled by elevation of the part and local pressure. The use of a tourniquet requires skill and caution and should be reserved as a last resort.

POTENTIAL COMMON DENOMINATORS OF ALL EXTREMITY INJURIES

Regardless of the location or nature of the injury, the nerves and circulation of the extremity may be damaged. Always verify the functional integrity of the motor and sensory nerves to the fingers or toes and the circulation of the hand or foot.

Contusions

The significance of a contusion depends upon crushed tissues and an escape of blood into intercellular spaces. The area should be rested until the bleeding has stopped. A temporary compression dressing is justified by progressive or extensive swelling, but should extend from the bases of toes or fingers to a level somewhat proximal to the injury. After cessation of active bleeding, gentle progressive resumption of motion and use is both safe and beneficial.

A hematoma often results from a contusion and usually subsides spontaneously. Persistent or large hematomas warrant aspiration by a large-bore needle followed by a pressure dressing and temporary local rest. If this is unsuccessful or followed by recurrence, operative removal of all blood clots and surgical obliteration of the hematoma cavity may be required.

* Prepared by Harrison L. McLaughlin, M.D., F.A.C.S., New York, and sponsored by the American Association for the Surgery of Trauma.

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If the extramarginal lacerations are superficial, only cleansing and simple coaptation are necessary. The edges of the wound are brought together either by interrupted sutures or by butterfly strips of adhesive tape. Simple suture of the edges of the defect is satisfactory if less than a third of the margin of the lid is missing. Deep lacerations are sutured in layers, after thorough cleansing. The conjunctiva and the expansion of the aponeurosis of the levator muscle are brought together with interrupted silk sutures, after which the skin and orbicularis muscle are similarly closed. Even when the wound is contaminated, a moderately heavy pressure dressing will serve as a satisfactory substitute for drainage.

Abrasions

Corneal abrasions may occur from surprisingly trivial causes, such as a scratch with the sharp corner of a piece of paper. They may also follow the removal of a foreign body, or may be caused by various types of military injuries. Most of them heal promptly because the corneal surface, even though it may lose most of its epithelium as the result of even a trivial injury, is capable of complete re-epithelization within 24 hours. Prompt healing, however, does not occur in patients whose upper lids are so constructed that in effect, particularly if edema is present, they create suction between the lid and the globe. Pain is severe and secondary iritis is the rule.

In such cases débridement may be necessary. It is best performed by the ophthalmic surgeon, even though it is a relatively simple procedure. The eye is thoroughly anesthetized. Then, with the lids held apart with a speculum, the loose corneal epithelium is rolled back from the abrasion with a tightly wound cotton applicator. Sometimes only a small rim of normal tissue remains around the limbus, but no matter how extensive the involvement, débridement is continued until all loose epithelium has been removed. The edge of the epithelium left in situ is cauterized with phenol or with a 50 per cent solution of trichloracetic acid applied with a pointed applicator. The original abraded area of cornea is similarly treated if it is infiltrated or infected. In this kind of case atropine or some antibiotic ointment is useful.

Lacerations

Whenever a laceration of the eyelids is present, the eye itself must be carefully inspected for possible damage. Whenever a laceration involves the eyeball, the possibility of an intra-ocular foreign body must be borne in mind

No matter what the diagnosis, no attempt should be made to remove the foreign body or to excise anything at all, including apparent blood clots. Prolapsed iris tissue has the appearance of blood clots, and an

the missile may remain embedded in the tissues. When the wound is made by a penetrating instrument, this agent may be withdrawn completely, or it may break so that a portion remains in the tissues. In any case, the basic problems confronting the surgeon involve infection and tissue damage.

A common denominator of all penetrating wounds is the risk of anaerobic infection. Test for sensitivity to horse serum and administer fifteen hundred units of tetanus antitoxin in a single or divided doses as indicated by the skin test. If previously immunized, administer a "booster" dose of tetanus toxoid.

Ascertain the functional continuity of all bones, muscles, tendons, nerves, and large vessels throughout the involved area. Division of an *essential anatomic structure in the tract of penetration demands repair.* The necessity for early repair of an essential structure constitutes one of the few indications for operative exploration and débridement of a deep-penetrating wound. Otherwise, débridement should be limited to the enlargement or superficial excision of the wound of entry, if this is necessary to insure adequate drainage.

Easily recovered missiles or fragments of the penetrating agent may be removed, *but deeply buried objects rarely justify the additional* tissue insult and increased risk of infection attendant upon their recovery. If a penetrating wound is laid open for removal of a superficial foreign body, e. g. a splinter of wood, it should be left open and treated as an infected wound until healing occurs by secondary intent. Few, if any, penetrating wounds should be sutured.

If the causative agent was clean, the small wound of entry may be expected to heal uneventfully. *If the offending agent or its path of* entrance was dirty, the entrance wound should be prevented from sealing over too rapidly, if necessary by the temporary insertion of a small rubber drain. When infection supervenes, appropriate antibiotic therapy and adequate drainage must be maintained until the process subsides.

Tooth bites create penetrating wounds accompanied by special *hazards. The laws of many states require all dog and cat bites to be* reported, and to be cauterized with fuming nitric acid which is said to kill the rabies virus Clinical evidence justifies such cauterization whenever the animal cannot be kept under observation, but it should be remembered that indiscriminate cauterization transforms many simple puncture wounds into deep chemical burns.

A horse bite creates a markedly contused and infected laceration and *should be treated accordingly.* Rodent bites may *transmit* rat bite fever, even though they heal uneventfully. Poisonous snake bites should be incised, sucked, a tourniquet applied proximal to the lesion, and supportive therapy administered. Whether the venom is neurotoxic or

early repair or prolonged (minimum eight weeks) immobilization of the part. A fracture of the fibula proximal to the level of the interosseous ligament, in the absence of a tibial shaft fracture, indicates a complete rupture of the tibiofibular ligaments until proven otherwise. Widening of the interosseous space or lateral shift of the talus with an intact lateral malleolus signifies rupture of the interosseous ligaments. Displacement of the talus away from an intact malleolus in excess of 0.5 centimeter by roentgenogram indicates rupture of the collateral ligament binding the talus to that malleolus.

Ruptures of muscle and tendon seldom occur in the young. Muscle belly is seldom the site of a complete rupture, except in the presence of antecedent weakness due to hematoma or neoplasm. Rupture often occurs at a musculotendinous junction, but the most common site is at the point of greatest attrition in the tendon of insertion. The clinical significance of a complete rupture through tendon or muscle depends upon the importance of the injured structure to normal function, and the presence or absence of compensatory structures. Thus a rupture of the plantaris is of no functional significance and adequate treatment consists of measures designed to control the symptoms pending their spontaneous subsidence. A rupture of the adjacent tendo achillis, however, constitutes a major and permanent disability and deserves early repair followed by control of calf muscle force until healing occurs. Spontaneous healing of ruptured Achilles, quadriceps, or patellar tendons usually is precluded by retraction. Avulsion of muscle origins from the anterior superior or anteroinferior spines of the ilium, or from the tuber ischii, on the other hand, seldom retract sufficiently to prevent healing by fibrous tissue even though these lesions involve muscles equal in force to the calf and quadriceps group. Operative repair is not often necessary in the latter lesions, and an excellent result may be expected from a conservative régime designed to control symptoms, rest the extremity, and prevent undue stretch or sudden contracture of the injured muscles.

In the upper extremity, the musculoskeletal mechanism is more complex, but the absence of any weight bearing demand somewhat reduces the significance of many muscle and tendon ruptures. A rupture of the long tendon of the biceps is common and, although productive of a cosmetic defect, seldom results in residual symptoms or disability, since lost function is compensated for by the short head of the muscle A long-standing rupture of the long biceps tendon associated with shoulder pain and disability is usually indicative of a rupture of the cuff tendons in the shoulder. Shoulder cuff rupture should not be repaired, except when demanded by the persisting symptoms and disability it has produced. Many such lesions are compensated for by adjacent intact cuff attachments. Avulsion of the distal

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Recent experimental evidence suggests that high concentrations of glucose in the blood stimulate the pituitary gland to produce the adrenocorticotrophic hormone (ACTH). If so, this may explain why the routine described is so effective in the properly selected (early) case.

Thermal Burns

Burns of the eyelid are treated like burns of the skin elsewhere in the body. Irritating medicaments should be avoided. No matter what care is exercised, it is almost inevitable that some of the substance will eventually seep into the eyes. In third degree burns, when extensive loss of skin is inevitable, protection of the eyeball by some one of the measures previously described is of paramount importance.

Burns from flames, as already pointed out, do not ordinarily affect the eyeballs because of the protective effect of the eyelids. The eyes must be carefully examined, however, before this is taken for granted. If there is no objective evidence, probably no injury has been sustained.

Burns which involve the upper face and areas about the eyes present special problems because of the great tendency to early contracture, with deformity of the lids. The best plan is to employ massive sterile dressings over fine-mesh gauze impregnated with petrolatum, in combination with the usual measures to prevent or correct shock and to control pain If the eyeball is undamaged, some ophthalmic ointment is instilled into it and it is included in the dressing, being left undisturbed until the dressing is changed. If there is visible evidence of injury, including mild superficial burns of the conjunctiva and anterior cornea, simple cleansing is all the local treatment necessary except for the application of sulfa or aureomycin ointment or 1 per cent atropine ointment. If there is marked inflammation, mild antiseptic ointments, such as White's bichloride of mercury ointment, may be applied several times daily. Healing is usually quicker than with chemical burns, and there is less tendency for chronic inflammation and late vascularization.

Full thickness burns of the cornea and sclera are infrequent. They are usually caused by spattering of molten metal and are, therefore, relatively small. Severe burns of the lower fornix will be followed by symblepharon unless steps are taken to prevent it. If the burns are of limited extent, it is usually sufficient to have the patient exercise his eyes several times daily in all directions. If they are more extensive, the necessary manipulations must be carried out by the ophthalmologist.

If the patient is unconscious and his eyes are open, suture closure may be necessary.

Some of the more severe burns of the eye may be treated with hydrosulphosol in oil, with gentle pressure dressings. There is no general agreement about the advantages of this regimen. Healing is frequently satisfactory but is not remarkable.

MANAGEMENT OF ACUTE PERIPHERAL NERVE INJURIES

Some controversy exists concerning acceptable methods of treatment of acute peripheral nerve injuries of civilian life. The differences of opinion do not stem from any fundamental issue but rather from contrasting approaches to the desirable end-point of the earliest possible nerve suture compatible with maximal anatomical and functional reinnervation. An effort is made in the following notes to present all aspects of the modern management of acute peripheral nerve injury in a dogmatic fashion in keeping with the objectives of this and other chapters

I The first principle of management has to do with the diagnosis or recognition of the fact that a peripheral nerve has been injured. The three major nerves of the upper extremity and the two of the lower extremity present unequivocal evidence of dysfunction when severed or when the impact of trauma temporarily depresses axonal conduction. The evidence is as follows.

A. Ulnar nerve. Loss of pain appreciation to sharp pin stimulus over distal two phalanges of the little finger.

B Median nerve. Loss of pain appreciation over distal phalanges of index or second finger.

C Radial nerve. Loss of extension of wrist.

In the lower extremity, the components of the sciatic nerve are studied separately; a combination of findings denotes sciatic nerve injury

D. Peroneal nerve. Loss of dorsal flexion of ankle and toes.

E Tibial nerve. Loss of plantar flexion of ankle and toes.

A sensory loss over the lateral aspect of the foot is present in tibial nerve injuries below the mid-calf.

Complicated nerve injuries of the brachial and lumbosacral plexuses may be defined by an evaluation of their separate peripheral nerve components. Characteristic hand postures may be noted at the time of acute injury but are not as well defined as they may be when muscle atrophy and shortening have occurred.

II. The second principle of management has to do with the selection of cases for immediate or deferred nerve repair. Cases suitable for immediate repair are as follows:

Prepared by a special committee of The Harvey Cushing Society composed of the following: Barnes Woodhall, M D., F.A.C.S., Durham, Chairman, Loyal Davis, M D., F.A.C.S., Chicago, and Henry G Schwartz, M.D , F.A.C.S , St. Louis.

C. The techniques for immediate or deferred nerve repair are essentially similar. They include
   1. Accurate identification of tissue.
   2. Complete removal of pathologic nerve ends to normal appearing fascicles.
   3. Accurate apposition of nerve ends with prevention of rotation of nerve segments.
   4. Use of interrupted epineural sutures of fine nonabsorbable material, preferably silk or tantalum.
   5. Completion of suture without tension. In nerve wounds with considerable—3 cm. or more—loss of nerve substances, suture-line tension must be obviated by joint posturing and by nerve segment mobilization and transplantation procedures.
   6. Meticulous care in handling of neural tissue.
   7. Placement of single metallic epineural suture 1 cm. from suture-line in distal and proximal nerve segments for postoperative x-ray check of possible suture-line disruptions.
   8. Protective casting of extremity, allowing adequate mobilization of metacarpophalangeal and phalangeal articulations, for minimum time period of four weeks.

IV. The fourth principle of management has to do with preserva*tion of the effector mechanism during the prolonged period of re*innervation of muscle This may be carried out by
   A. Gradual extension of flexed joints through physiotherapy and passive movement beginning when cast is removed.
   B. Galvanic stimulation and active massage of paralyzed muscles.
   C. Intermittent splinting of paralyzed muscles in a position of functional relaxation.

V. The last principle of management has to do with the care of acute peripheral nerve injury which may be classified as irreparable because of extensive loss of peripheral nerve tissue. Such cases should be referred for orthopedic rehabilitation, as soon as the irreparable nature of the nerve wound is recognized. The potential value of autogenous nerve grafts is recognized, their use requires a specialized experience.

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When the irrigations are concluded, some analgesic agent is introduced to control pain and blepharospasm. Pontocaine is particularly useful because of its hardening effect on the corneal epithelium. Fluorescein is then applied and the eye is flushed with physiologic salt solution. This procedure is repeated twice. If at the end of the third application no stain is present, it may be concluded that a true chemical burn, in the sense of cell damage, has not occurred. If staining is still present, the patient must have competent ophthalmic care as soon as possible. With application of pontocaine (0.5 per cent) and of ointment containing bacitracin or aureomycin, healing usually occurs within from 24 to 48 hours, though it is not possible to say in which cases it will or will not occur. Cortisone ointment has been found to be of some value. Hydrosulphosol is about as effective as in thermal burns, which means that it is not highly recommended.

1. Immobilization should be employed as soon as possible after receipt of the injury as protection from further tissue damage.
2. Following definitive treatment of the injury, the immobilization should be continued as long as may be required for healing to occur.
3. Immobilization should be in the position of function* (position of grasp) in order to maintain optimum relation of bone fragments and soft tissue structures.
4. The position of function in immobilization is necessary to prevent disabling deformities, contractures, muscle weakness and joint stiffening, and to insure the earliest return to usefulness after healing.
5. Flat splinting of the hand or any of its digits must be avoided at all times.

II. REQUIREMENTS OF EARLY DEFINITIVE TREATMENT

The general requirements for proper early definitive care are

A. Thorough Evaluation of the Injury

1. Determination of the time, place, causative agent and mechanism of the injury.
2. Determination of the nature and extent of the first treatment given.
3. Determination of infection status—whether the wound is relatively clean, contaminated or with infection established.
4. General nature of the wound, i.e. contusion, abrasion, burn, incised wound, lacerated wound, crushing wound, puncture wound, tooth wound, imbedded foreign body, fracture, open fracture, amputation or combined injuries.
5. Evaluation of structural damage.
   a. Degree and extent of surface injury.
   b. Source of major bleeding.
   c. Evidence of tendon or muscle damage by testing function against resistance.
   d. Evidence of nerve injury elicited by testing for motor and sensory functions.
   e. Bone and joint injury determined by x-ray.
   f. Discovery and exact localization by x-ray of suspected opaque foreign bodies.

B. Adequate Facilities and Equipment

1. Each hospital or clinic should have at least one surgeon who is

*Position of function or position of grasp: Wrist hyperextended in cock-up position; fingers in mid-flexion and separated; thumb abducted, slightly forward from hand and slightly flexed.

and hand immobilized to such extent as may be necessary to permit healing, in the position of function (never in the flat position).

10. Administration of antibiotics and protective antitoxin as indicated.

D. Aftertreatment

1. Elevation and rest of the hand.
2. Noninterference with initial dressing for a sufficient time to permit healing, unless evidences of suppuration develop.
3. Restoration of skin coverage of denuded areas at earliest possible time. Partial thickness skin grafting is a simple and valuable means of promoting primary healing.
4. Early restoration of function for nonaffected parts of the hand by directed active motion to the fullest extent that will not jeopardize healing of repaired structures.
5. Restoration of function in affected parts of the hand by directed active motion as early as is consistent with full healing and preservation of the repair of damaged structures.

III. SURFACE INJURIES

Burns, abrasions and avulsions may cause destruction and denudation of any area of the skin of the hand. The care of such injuries has three major objectives: (1) protection from infection; (2) early restoration of skin covering; and (3) avoidance of disabling scarring and contractures. These objectives are sought in the various stages of treatment.

A. First-aid Treatment

1. Chemical burns. Remove chemical by profuse irrigation with water.
2. Heat burns, abrasions and chemical burns. After washing away the injuring agent, apply sterile dressing to cover the hand completely and bandage firmly.

B. Definitive Treatment

This consists of dressings, mostly, but often includes skin-grafting. The first dressing should be carried on in the operating room under conditions of strict asepsis. The operator and assistants and patient must wear masks.

1. Gentle removal of first-aid dressing, soaking loose with normal saline solution if necessary.
2. Gentle cleansing of injured surface by light sponging with saline on cotton balls. If surface is dirty or greasy, it may be gently cleansed with sterile neutral soap in sterile water or bland detergent. Loose fragments and tags of skin are removed.

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Patients with wounds which do not involve the important structures outlined above are treated as follows:

1. Protect the open wound with a sterile dressing while cleansing a wide surrounding area with plain soap and water. Hairy parts are shaved.
2. Infiltrate the margins of the wound through the intact skin with a one per cent solution of procaine.
3. Cleanse the wound and excise devitalized tissue.
4. Close the wound with the least number of interrupted nonabsorbable sutures necessary for adequate approximation without tension.
5. Apply a sterile dressing and supporting bandage.
6. Tetanus antitoxin, or tetanus toxoid, and antibiotic medication should be given when circumstances and the nature of the wound warrant this treatment.

Constricting bandages should not be applied to the neck of any patient who is unconscious, or may become so following medication, unless there is someone in attendance to guard against strangulation from hemorrhage, edema, or any other cause for tracheal obstruction or venous compression.

It is sometimes advisable to transport these patients in a prone position when the presence of tracheal or esophageal injuries renders possible fatal aspiration of secretions, vomitus, or blood.

In the case of patients who require more adequate facilities, the wound should be covered with a sterile dressing of appropriate size, and the patient should then be sent to a hospital where the care necessary for such wounds is available. Even in the well equipped emergency room probing of neck wounds and removal of blood clots should not be done unless one is prepared to control hemorrhage and supply blood in a volume sufficient to prevent or overcome shock. However, the urgent case must be cared for promptly.

Injuries to Air Passages

Respiratory obstruction may result from aspiration of blood or a foreign body, direct trauma to the larynx or trachea, edema due to injuries to adjacent structures in the neck or floor of the mouth, or increased pressure in the neck due to hemorrhage from an artery, large or small.

Respiratory obstruction when impending, or likely to occur from the nature of the neck wound, warrants immediate hospitalization lest an urgent condition be precipitated. Morphine should not be given to a patient with impending obstruction.

When strangulation is already present or developing, immediate tracheotomy is necessary. Done soon enough, even under the most unfavorable circumstances, it may be lifesaving. Inspiratory indrawings at the suprasternal notch, supraclavicular fossae and epigastrium, indicates the urgency of the condition.

These objectives are furthered by proper first-aid care as outlined earlier, and by definitive treatment, as follows:

A. Definitive Treatment

To be undertaken only under the proper conditions and according to the principles already outlined. Careful history of the injury should be followed by examination of the hand to determine:

1. Location and extent of the wound.
2. Source of major bleeding.
3. Presence of foreign material.
4. Function of tendons, to be tested against resistance.
5. Function of intrinsic muscles.
6. Condition of nerves as regards both sensory and motor functions.
7. Integrity of bone and joint.

Following anesthetization of the patient and application of hemostatic blood pressure cuff (not to be inflated above 300 mm.), the definitive treatment of the wound consists of

1. Thorough cleansing of the wound region and then of entire hand and forearm with soap and water or bland detergent.
2. Removal of foreign material from the wound.
3. Careful, gentle, thorough but conservative excision of devitalized tissue, sparing all structures that may survive.
4. Repeated cleansing of wound by irrigation with warm physiologic saline solution.
5. Securing and ligation of divided blood vessels.

These general measures are followed in appropriate cases by repair of damaged structures. Proper wounds for this repair are (1) those in which infection has not become established; (2) those not grossly contaminated by highly infective material; and (3) relatively clean wounds not more than three or four hours old.

In general, wounds not fulfilling these criteria are better left unrepaired to await secondary closure and later reconstructive surgery. They should, nevertheless, be as carefully cleansed of foreign matter and dead tissue as are those prepared for primary closure. In such cases severed nerve ends may often be repaired or, if the surgeon is concerned, they may be identified with nonabsorbable sutures or lightly united

B. Repair of Damaged Structures

1. Nerves
   a. All severed nerves should be repaired, including the digital nerves
   b. Fine arterial silk on fine needles should be used, accurately approximating the nerve ends by small interrupted sutures

7. Dressing. Firm pressure dressing is applied, the fingers being separated, with gauze between them. The hand is immobilized by splinting in the position of function, except when suture of severed tendons requires splinting in a position to insure the least strain on their suture lines. The position of function is particularly important if nerves have been severed to prevent deformity due to contracture of active muscles when their opponents are denervated and paralyzed.

C. Aftercare

1. Antibiotics and tetanus antitoxin (or toxoid) are administered systemically as prophylaxis against infection.
2. The extremity is kept elevated for the first three or four days.
3. Dressings are not removed for several days, usually one week, unless infection develops.
4. The healing of severed tendons and nerves requires three weeks of uninterrupted immobilization
5. When nerves are severed, corrective splinting is necessary until re-innervation of paralyzed muscles has occurred.
6. Restoration of function is best secured, after healing, by directed voluntary exercise and appropriate occupational therapy.

V. FRACTURES AND DISLOCATIONS

The purposes of treatment of closed fractures and dislocations of the bones of the hand are (1) protection of the injured bony structures from further displacement and avoidance of added damage to soft parts; (2) restoration of normal relations of the bony structures; (3) maintenance of the corrected relation of the bones to permit healing, at the same time avoiding stiffening in position of non-function; and (4) restoration of function These objectives are sought in the various stages of treatment.

A. First-aid Treatment

1. Avoid manipulation or attempts at reduction until skilled attention is available and accurate diagnosis has been made.
2. Prompt protection of the hand by complete immobilization in the position of function pending definitive treatment.

B. Definitive Treatment

When proper skill and facilities are available, this consists of

1. Diagnosis by means of

   [illegible] to determine *swelling, ecchymosis, deformity, loss* [illegible] function.

   [illegible]ation, gently employed, to discover bony irregularity,

7. Dressing. Firm pressure dressing is applied, the fingers being separated, with gauze between them. The hand is immobilized by splinting in the position of function, except when suture of severed tendons requires splinting in a position to insure the least strain on their suture lines. The position of function is particularly important if nerves have been severed to prevent deformity due to contracture of active muscles when their opponents are denervated and paralyzed.

C. Aftercare

1. Antibiotics and tetanus antitoxin (or toxoid) are administered systemically as prophylaxis against infection.
2. The extremity is kept elevated for the first three or four days.
3. Dressings are not removed for several days, usually one week, unless infection develops.
4. The healing of severed tendons and nerves requires three weeks of uninterrupted immobilization
5. When nerves are severed, corrective splinting is necessary until re-innervation of paralyzed muscles has occurred.
6. Restoration of function is best secured, after healing, by directed voluntary exercise and appropriate occupational therapy.

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When possible, the advice and services of a laryngologist should be sought for the care necessary to prevent the sequelae of these injuries.

Injuries to Vessels

Bleeding from superficial vessels is controlled by ligation. When injury to a large vessel is suspected or actually present, manipulation of the wound should be avoided lest disturbance of a protective blood clot result in uncontrollabel hemorrhage. Care of injuries to large vessels requires blood for replacement, intratracheal anesthesia, oxygen, adequate assistance to aid in exposure of the wound and control the blood flow in the carotid, or innominate or subclavian arteries (and one or two of these vessels may require control to help locate and ligate a bleeding vessel or vessels), suture material and instruments of proper *size and design, adequate lighting, and nursing care.*

Unless these facilities are available, and pending transportation to a hospital, the wound should be covered with a *compression dressing* held in place by adhesive tape which does not encircle the neck, or by manual compression.

Penetrating or perforating wounds of small size associated with severance or perforation of large vessels may be accompanied by little or no external bleeding. The neck becomes swollen because of venous compression and accumulation of blood in the fascial spaces. This is commonly associated with difficulty in breathing due in part to tracheal compression and in part to factors associated with increased pressure in the neck but not related to a decrease in size of the airway.

It is of some value to distinguish between strangulation due to a defect in the airway and strangulation due to internal tension in the neck. Decompression of the fascial spaces by incision into them will relieve the respiratory difficulty, but the bleeding point must now be controlled lest fatal hemorrhage ensue. Intratracheal anesthesia with a high oxygen content is extremely useful. Operating procedure is as follows:

1. Skin incision over the anterior border of the sternomastoid muscle on the side of the injured vessel.
2. Compression by stick sponge over site of injury.
3. Isolation of carotid artery below the wound with application of tape sling.
4. Isolation of carotid artery and jugular vein above the injured site with application of tape slings.
5. Exposure of the injured segment of vessel, and wound cleansed of clots, loose tissue, and tags.
6. Closure of artery wound either by a continuous nonabsorbable suture (0000 on needle) or ligation with a braided silk ligature close to adjacent branches with removal of the damaged segment. The smaller the caliber of the artery the finer the ligature necessary to occlude the lumen. Veins are ligated close to branches to avoid sacs of non-

C. Maintenance of Reduction

Immobilization of bony injury following reduction should

1. Be secure with firm, even pressure bandaging, permitting no motion at site of injury.
2. Be nonconstricting, not interfering with circulation.
3. Be comfortable, causing no excess pressure.
4. Preserve, as far as possible, the position of function, taking into account the normal concavities of the palmar surface of the skeletal structure (arches of the hand) and flexor surface curves of the phalanges. (Wrist in 30-degree dorsiflexion, metacarpophalangeal and distal interphalangeal joints in 45 degree flexion, and middle interphalangeal joint in 90 degree flexion.) Flat splinting is to be condemned.
5. Leave free to move all joints whose motion will not jeopardize position and healing. During immobilization, active motion of all joints not necessarily confined is to be encouraged.

Immobilization may be accomplished by

1. Splinting or plaster casing.
2. Internal fixation. Kirschner wires may be employed, following either open or closed reduction, as axial intramedullary splints for individual long bones (not to protrude into a joint); as transversely introduced fixation pins passing through adjacent bones to secure the fragments of metacarpal fractures; as penetrating fixation for fragments of carpal fractures.

Wiring or plating of fractures of the bones of the hand is generally unsatisfactory

During the early period of immobilization, elevation of the hand is desirable. Immobilization of the injury should be consistent and continuous until healing and firm union have been established

Healing of ligamentous injuries accompanying dislocations requires two weeks of immobilization following reduction.

Healing of fractures of the long bones requires immobilization for three to five weeks

Healing of carpal bone fractures requires 12 to 14 weeks' immobilization Fractures of the navicular may require four months to unite. If immobilized consistently for this length of time, most of these fractures will not require surgical intervention.

D. Restoration of Function

During the healing process, all joints not necessarily immobilized should be freely moved to activate their controlling muscles and their use by the patient encouraged.

Maximum skin coverage should be provided at once by (1) utilization of local skin; (2) free split-thickness grafts; or (3) employment of an abdominal or thoracic pedicle graft.

Where the skin loss is extensive, or in stripping or denuding amputations of digits (especially the thumb), leaving bone exposed, the application of a pedicled skin graft is desirable.

Local skin should not be employed if the preparation of flaps requires further amputation or sacrifice of living bone. Thus, the stump of an amputated digit should be left at full length and be covered by appropriate graft, either immediate or delayed. Sacrifice of finger length by formal reamputation is to be condemned.

Partially amputated parts of digits should be retained and lightly sutured in place with skin stitches only. Many will survive and may subsequently be restored to usefulness.

5. Retention of reduced incidental fractures or dislocations by appropriate splinting or fixation.
6. Application of firm pressure dressing, the hand (except when fixed to the body for grafting) being splinted in the position of function.
7. Administration of tetanus antitoxin and antibiotic drugs.

C. Subsequent Care

1. Dressings. Unless evidences of infection develop, the dressing should be left in place for a sufficient time to permit healing of initially closed wounds or the firm taking of grafts (seven to ten days). Coincidental fractures require additional periods of immobilization to assure union
2. Surface healing. If skin coverage has not been completed at the time of initial definitive treatment, or if grafting has failed, preparation should be made to place or replace skin grafts at the first postoperative dressing. Denuded areas should be given skin coverage at the earliest possible time
3. Restoration of form and function. When healing is complete a program should be developed and prosecuted for (1) restoration of function by exercise and occupational retraining; (2) reconstructive surgery to render the hand remnant as useful as possible, or (3) preparing the stump for prosthesis.

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healing occurs without suture, but repair of large rents is desirable in order to avoid persistent leakage of secretions. Feeding through a nasal catheter is desirable for a period of a few days to one week, depending on the size of the opening. Extensive wounds of the pharynx or esophagus may heal better without an indwelling catheter. The establishment of a gastrostomy or jejunostomy may better accomplish maintenance of nutrition without interfering with the healing process in the neck. Following necessary care at the site of injury, the skin is closed loosely, and a drain put into the fascial space.

Wounds Adjacent to Jaws, Chest, Axilla, Head

The bony barrier between the neck and chest is the first rib on each side, attached to the sternum. The bony barrier between the neck and axilla is the clavicle on each side. These barriers between adjacent zones of soft tissue interfere with the freedom of manipulation which is frequently necessary to cope with wounds of the neck extending to the chest or axilla.

The floor of the mouth and mandible are also frequently injured in wounds involving the neck. Thus, these zones adjacent to the neck must be studied and, when necessary, exposed in order to complete the care of injuries to important structures (blood vessels, food and air passages). The control of blood flow in the carotid, innominate and subclavian arteries must not be undertaken lightly in an emergency room. The possibilities of the complications noted above emphasize rather the need for the careful examination, evaluation, and triage of patients with neck wounds.

Concomitant Injuries

Failure to examine the rest of the body of the patient who has a severe neck injury may be cause for an avoidable disability or a fatal issue, even when proper care for the neck wound has been carried out. Thus, the casual survey of the initial examination must be followed by more thorough study by all personnel who are charged with the responsibility for the care of the patient. An unreduced dislocation of a thumb may be insignificant when compared to a life endangering wound in the neck. However, while he may recover from the neck injury, the patient may be left with a disabled hand.

In the upper extremity, where free motion and manual dexterity are most important, every effort should be made to preserve all possibly useful parts. A badly crushed finger should be saved if there is any chance of useful function. (Conversely, a badly crushed toe which would require prolonged treatment and which would be likely to end as a deformed, painful digit, should be promptly amputated.)

Complete and permanent loss of circulation is the one definite indication for amputation. Loss of bone alone, even though it may be extensive, does not indicate amputation if the function of the extremity distal to the injury is still good. Extensive loss of nerves, tendons, bones, joints and skin in any part may make it practically impossible to restore function. Occasionally the advisability of amputating or saving a part can only be decided after a trial of treatment, but usually this can be determined by careful examination at the time of injury. When amputation is indicated or is inevitable, the earlier it is done the better. This is especially true in the case of a severly injured finger. The whole hand may be completely ruined by a misguided attempt to save a single useless digit. However, every effort should be made to save all or part of the thumb.

The necessity for amputation as a lifesaving measure because of a fulminating infection, such as gas gangrene, is fortunately now rare, but may still be indicated occasionally. For a malignant growth in an extremity, amputation usually offers the best chance of cure. This should not be delayed, and should be radical enough to insure a chance of success. Even if amputation fails, and it often does, the operation will generally serve the merciful purpose of making the last days much more bearable for the patient. The local resection of a malignancy, which may be considered more conservative, is difficult technically, is seldom complete, and usually leaves a markedly disabled and often useless extremity. Amputation therefore should usually be the method of choice for this condition.

For peripheral vascular disease or embolism amputation may be *necessary to save life. Certainly it will often rid a patient of a painful and* useless extremity and return him to a more normal life even though a prosthesis is necessary.

An amputation to improve function may be indicated in any instance where normal function has been lost and where the part has become an impediment to which usefulness cannot be restored. Extensive chronic infection such as osteomyelitis or tuberculosis, trophic changes such as leprosy or Charcot joints, congenital or acquired deformities, or gross inequality of the leg length are sometimes indications for amputation. One should hesitate in advising amputation of a paralyzed extremity, however, as good muscle power in the stump is essential if an amputee is to use a prosthesis.

should be removed, but living tissue, especially skin, should be retained. The completion of a traumatic amputation through the site of injury should be done in the same way, retaining as much viable skin as possible. The "guillotine" amputation should not be used except possibly at the ankle for a hopelessly crushed foot.

In an open amputation as little as possible should be done, other than the débridement. Nerves and tendons are sectioned cleanly through noninjured parts and allowed to retract. Blood vessels are ligated. No sutures are inserted. Vaseline gauze can be used on the raw areas. These open amputations should not be expected to give a final stump, suitable for a prosthesis, but if skin traction is applied at once and maintained constantly, it will produce a well formed conical stump with soft parts adherent to the bone. This can later be converted by a simple plastic revision into a very satisfactory permanent stump, with little or no loss of length.

Skin traction must be begun at the time of operation. The combination of skin glue and stockinette is most efficient. The stockinette tied over the end holds the dressing in place. Five to ten pounds of weight keep the skin from retracting, and prevent contracture of the knee or hip. This weight should not be removed to relieve pain as it does not cause pain. The patient may be allowed up on crutches, but traction must be continued, even when up, until all tissues are adherent to the bone.

Revisions. Revision of open amputation should be delayed until the wound is closed or almost healed and clean. All edema should be gone from the end of the stump. The scarred skin, ulcer at end (if still present), and the tip of the bone can be removed in one mass, cutting through healthy tissue. The skin and subcutaneous tissue can be mobilized enough so that the skin can be closed over the bone end, leaving the muscles and fascia still adherent to the bone. The exact position of the scar is not too important as long as healing is prompt and the skin not adherent to the bone.

Reamputations. For unsatisfactory stumps reamputation instead of revision should be done if the stump is too long This is most often indicated in long below-knee stumps. Unsatisfactory stumps at, or just below, the knee may justify an above-knee reamputation.

Closed Amputations Wherever an amputation can be done through a clean field, with little danger of infection or other complication, the operation should be carefully planned and executed to provide a final stump which will be as nearly perfect as possible. A tourniquet is usually desirable but this should always be removed and bleeding controlled before closure is done. Anterior and posterior skin flaps are made so that they can be brought together over the bone ends with the same tension as normal skin. In the upper extremity and thigh these should be about

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respiratory physiology, the control of hemorrhage, and the prevention of infection. The control of hemorrhage is carried out in essentially the same manner as in other parts of the body and prevention of infection poses no problems peculiar to the thorax, so neither subject is discussed in detail here. On the other hand, certain injuries produce important changes in cardiorespiratory physiology, changes which give rise to characteristic symptoms and signs. It is necessary that the physician who has the responsibility for the care of patients with thoracic injuries be familiar with these physiologic changes, the manner in which they are produced, the physical signs and symptoms associated with them, and, finally, the most effective measures for their relief.

Several all important conditions develop only as a result of chest injuries. These may occur singly or in combination in patients with chest injuries from any cause. Unrecognized and therefore without proper management, the results are necessarily poor. If recognized and their mode of production is understood, treatment may be simple. These conditions are as follows:

1. Retention of bronchial secretions with inadequate pulmonary aeration, caused by:
   a. Severe chest wall pain
   b. Abnormal mobility of the chest wall
   c. Depression of the cough reflex through
      (1) Unconsciousness
      (2) Administration of excessive amounts of opiates
2. Open chest wall with the "sucking sound" phenomenon. A similar condition physiologically is produced by extensive rib fractures with resultant excess mobility of a considerable segment of chest wall, the so-called "flail chest".
3. Pressure or tension pneumothorax with or without mediastinal emphysema.
4. Cardiac tamponade.
5. Massive hemothorax.

Since adequate treatment of these conditions will correct the resulting cardiorespiratory disturbances and thereby aid in resuscitation of the patient, each condition will be discussed in some detail.

Chest wall pain may have serious consequences in injuries which otherwise would be of no great importance. Pain may effectively immobilize the chest wall, thereby making cough ineffectual. This results in retention of tracheobronchial secretions and/or aspirated material. The accumulation of such material in the bronchi interferes with pulmonary ventilation and leads to atelectasis and perhaps even to suppurative pneumonitis If inadequately treated, such patients may actually go on to asphyxiation. Recognition of such a situation is not difficult.

daily exercises and stretching must be continued until the prosthesis is obtained.

If there are no contractures and the stump is well shaped, the incision well healed, and the muscular power good, there should be no difficulty in fitting a prosthesis. A temporary prosthesis is worthwhile only if there is going to be considerable delay in obtaining the permanent one. The surgeon, the physiotherapist, the limb fitter and especially the patient must work as a congenial team. The patient and the limbfitter must get together as often as necessary. Whether the limb is of wood, metal or plastic is of little importance. The fitting of the socket and alignment of the joints determine how well the prosthesis will function. At least six stump socks should be ordered as the patient is usually given only one.

CHECKING A PROSTHESIS

A surgeon need not be a trained mechanic to check a limb. The following points for an above-knee limb should be noted.

1. Length. The anterosuperior spines should be nearly level as patient stands Fitting the prosthesis a little short is sometimes better in elderly people.

2. Knee Joint. As patient sits, knees should be level. In walking the knee must flex and lock in extension.

3. Ankle Joint Should not allow any dorsiflexion.

4. Pelvic Band. This should remain against pelvis when unbuckled in either sitting or standing position.

5. Alignment. Foot should toe out the same amount as normal leg. Limb should balance itself on the ground.

6. Stability. The tester should be able to put all his weight on the ischial seat without having the knee give way.

7. Socket The ischial tuberosity should rest on the ischial seat. There should be adequate room at the adductor longus tendon. A "plug-fit" is not acceptable. For suction socket the fit must be even more perfect, or suction will be lost.

A below-knee limb should be checked for many of the same points, and most especially the fit of the socket. Any imperfections in the socket will show as pressure marks on the stump. The thigh corset should not be too short

For upper extremity amputees, accurate fit of the socket, good fit of the harness, and the ability to open and close the prosthesis in all positions are usually all that is needed.

When a prosthesis has been fitted and checked it is most important that too much immediate use be prohibited. The skin of the upper calf is not accustomed to weight bearing, and even the ischial tuberosity must be toughened up. Many good stumps are permanently ruined by too much activity when the prosthesis is first applied.

OPEN WOUNDS OF JOINTS

"It is from the disposition that the cavities of joints have to fall into the suppurative inflammation when an opening is made to them that the union by the first intention does not take place. . . . When they suppurate it is very tedious and then the parts are apt to die and slough which makes these accidents of such dangerous consequence."

—From a discussion of war wounds by John Hunter

OPEN WOUNDS OF JOINTS are seen as the result of

I. Direct violence in which the joint is opened by penetration, as from

1. Gunshot or other irregularly shaped missiles,
2. Sharp objects, such as spikes, glass, wood fragments, etc.,
3. Blunt forces directed at superficial joints, such as the knee or ankle, in the manner of falls directly against nonyielding surfaces or blows by heavy hammers, et cetera.

II. Indirect violence in which the joint capsule and covering skin are ruptured by the tensions produced in the displacement of fractures into joints, dislocations of joints or their combination.

The wounds may be classified as follows:

1. Those in which the injury is confined to the capsule and synovia without damage to bone or cartilage.
2. Those in which there is damage to articular cartilage, menisci, or labrum. These wounds may be further classified into those that have minimum, moderate or severe damage with loss of cartilage substance.
3. Wounds with additional injury to bone, either in the form of fracture with fragment displacement, amenable to reduction, or those with loss of bone substance.
4. Wounds with severe destruction of the major supporting ligaments and of the muscles and tendons that activate the joint.
5. Any of the above may be produced in a manner that does not involve actual penetration Such injuries are seen associated with fracture and fracture dislocation.

The *sine qua non* of the effective management of open joint wounds may be expressed in two thoughts. First, initial treatment should be carried out regardless of the time intervals. Second, it is the inadequate or timid performance of the débridement procedure which is the most common cause of subsequent sepsis.

The early resistance of synovia to infection has been stressed, and there is experimental evidence to substantiate such clinical observa-

Prepared by James K. Stack, M.D., F.A.C.S., Chicago.

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If the size of the opening approaches or exceeds the size of the glottis, the patient may get into serious difficulty. Other important factors are the type of wound and the mobility of the mediastinum. If the wound allows air to enter the pleural space but does not permit it to escape, the patient's condition deteriorates more rapidly. Since the mediastinum is usually quite mobile, open pneumothorax generally leads to a shift of the mediastinum to the opposite side with compression of the contralateral lung as well as the lung on the side of injury. The swing of the mediastinum with each respiratory cycle causes poor air exchange and also interferes with the return of venous blood to the heart.

Smaller wounds of this type which give rise to the characteristic sound of air entering or being expelled from the chest have long been known as "sucking wounds." Since this term has no significance apart from the altered physiology of an open pneumothorax, and since wounds often change from the closed to the open type, or vice versa, with changes in tissue plane alignment, there seems to be no logical reason to retain the term. All penetrating injuries of the chest wall are to be considered open (sucking) until careful inspection or actual débridement prove them to be otherwise.

Open wounds must be closed effectively as soon as possible. As an emergency measure a simple occlusive dressing of vaseline gauze is adequate. When the patient has been removed to a location where facilities are adequate, the wound is débrided and an airtight pleuromuscular closure is done. A large catheter (34F–45F) is inserted through an intercostal space into the pleural cavity and is connected to a waterseal arrangement (for evacuation of air and fluid). The wound will be discussed later.

Flail chest is always a serious occurrence and, if the mobilized segment of chest wall is large, it may even be life-endangering. Milder cases are adequately handled by intercostal nerve block supplemented by a stabilizing pressure dressing secured by elastic adhesive. More serious injuries may require the insertion under aseptic precautions of a sterile towel clip around the central rib of the flail segment and the application of light traction. Traction may be obtained by a cord attached to a weight, usually about five pounds, suspended over a single pulley attached to an overhead frame. The intercostal nerves of the involved area should be injected with procaine. Oxygen should be administered.

The terms "pressure" or "tension pneumothorax" indicate the accumulation of sufficient air in the pleural cavity to compress the lung and thereby seriously interfere with ventilation. If the mediastinum is not fixed by adhesions, the opposite lung may also be compressed.

Patients with pressure or tension pneumothorax are usually dyspneic and cyanotic. The combination of hypoxia and interference with

may not be safe, particularly if allowed to remain for a long period. After the area surrounding the wound is shaved and thoroughly cleansed, the joint is opened, preferably through a new exploratory incision designed to reach the area where most of the involvement is suspected. However, there will be cases where mere enlargement of the existing wound will suffice. This will be applicable usually to those instances where the joint involvement is confined to the region immediately beneath the opening.

All clots, pus (if treatment has been delayed so that suppuration is already present), and loose debris are removed by thorough irrigation. The débridement is then done and it must be as extensive as is indicated. All tissue which is contused, is obviously necrotic, or has dirt or foreign substances ground into it, must be removed. This includes articular cartilage, ligaments, bone, menisci, et cetera. If the articular cartilage is simply soiled, it may be gently cleansed with moist sponges, but otherwise layer on layer should be shaved off with a sharp scalpel until an uninvolved base is attained. Soiled bone surfaces are removed with a thin sharp osteotome.

During the performance of this step in the treatment, it should be remembered that the first objective is to prevent infection and the second objective is to restore the normal anatomy of the joint as nearly as possible. The first objective always takes precedence if a choice between the two is necessary. Thus, if an important ligament, tendon or section of articular cartilage is deeply involved, one should not hesitate to sacrifice it because, if suppuration intervenes, a poor result is inevitable. It may be thought at the time of the débridement that instability of the joint will follow the sacrifice of much of its supporting structure; however, as time goes on, the problem will be quite the opposite, as the remaining parts will so tighten that restoration of motion will be the objective, rather than restoration of stability. Again, the timid surgeon is the one whose joint débridement will be complicated by sepsis.

A decision as to the type, amount, and location of material used in intra-articular repair and fixation may be difficult, and no rule can be laid down concerning its use. Complete dependence will have to be placed on the surgeon's own estimate of the amount and depth of involvement if internal fixation materials are to be used. A minimal number of deep sutures should be employed, and it is permissible under favorable conditions to use metallic fixation in the repair. In open fracture dislocations of the ankle, we have usually used screw fixation of the medial malleolus.

Closure of the synovial sac should be watertight whenever possible, and the subcutaneous tissues should be left open for secondary closure at a later time or for healing by second intention. If there has been extensive loss of synovia and joint capsule, flaps of fascia may have to be

VASCULAR INJURIES

THE OBJECTIVE in the management of vascular injuries is to save the patient's life, his injured limb, and to maintain or restore as adequate circulation as is possible.

CONTROL OF HEMORRHAGE

Bleeding should be brought under control without delay. The method employed will depend upon the location and nature of the injury. Bleeding from veins, and even from small arteries, may often be stopped by prolonged digital compression of the bleeding point or by application of a snug compression dressing. Such efforts may be aided by elevating the extremity. Sometimes hemostasis may be effected by packing the wound with sterile gauze or, even better, by using one of the hemostatic absorbable materials, such as gelfoam or oxycel gauze. If ordinary gauze is used, it should be removed within a few days and, since recurrence of bleeding may take place, one should be prepared for immediate surgical exploration of the wound. Only on rare occasions should a finger be inserted into a wound in order to control hemorrhage since there is always danger of infection and of inadvertently increasing the size of the rent in the vessel. At times, the direct clamping of the injured vessel with a hemostat may be the procedure of choice. The clamp can be left in place until it is feasible to proceed with more definitive surgical treatment. Such a practice is best employed when the vessel is readily visualized and when it can be accomplished without hazard of injuring adjacent structures such as nerves and tendons, and particularly when there is every evidence that the bleeding vessel is not an important main stem artery. Clamping of an important main stem artery may damage it irreparably so that the simple closure of an incomplete laceration may be precluded. An ideal method which, unfortunately, cannot always be applied, is to control bleeding by compression of the proximal artery against a bony part. This can be maintained for brief periods only. When this method can be used to control bleeding and definitive treatment can be carried out with only a brief delay, the method is ideal.

If such methods are not applicable, one may have to resort to the use of a tourniquet. It must be remembered, however, that the use of a tourniquet, except as an expedient to be employed for a short time, dooms the extremity, because an effective tourniquet renders the limb entirely ischemic. Various devices may be used. In general, the tourniquet should, by preference, be wide rather than narrow. At times the

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thorax. Such a combination usually indicates a serious underlying injury. Collections of air limited to the subcutaneous tissues may reach startling proportions but fortunately, in the absence of gas-forming pathogens, seldom endanger life. Air under pressure in the mediastinum interferes with the venous return and may also cause tracheal obstruction.

Air gains access into the mediastinum through perforations of the esophagus, the trachea or mediastinal portions of the main stem bronchi. Also air may dissect along the bronchi and/or blood vessels and gain access to the mediastinum from the lung. In extensive mediastinal emphysema there is apt to be swelling of the neck. In some cases the mediastinal emphysema is associated with subcutaneous air. The diagnosis of mediastinal emphysema is made by hearing the so-called "mediastinal crunch" with the stethoscope and visualizing the air by roentgenography. In cases where air dissects up into the base of the neck the distinctive crepitation produced by air in the tissues is easily elicited.

Treatment should be directed toward correction of the underlying lesion. If a tension pneumothorax is present, a catheter is inserted into the pleural space and is connected to a water-seal device. If air is present in the mediastinum under sufficient pressure to cause labored respirations and circulatory impairment, a collar type incision should be made at the base of the neck and a finger introduced into the superior mediastinum, thereby permitting the ready escape of air. If the air in the mediastinum is the result of laceration of the trachea or esophagus, open thoracotomy is indicated.

Massive accumulations of blood in the pleural cavity may produce serious physiologic disturbances, as well as the effects of blood loss. These physiologic disturbances may be reductions in lung volume and vital capacity, reduced cardiac filling from obstruction of the mediastinal veins, and compression of the contralateral lung, the result of mediastinal shift. Recognition of these conditions is not difficult. These patients show dyspnea and pallid cyanosis, the percussion note is flat, and the breath and voice sounds are usually distant over the greater part of the chest, but the breath sounds may have a bronchial character posteriorly near the spine. Thoracentesis which produces a free return of blood confirms the diagnosis.

Treatment is directed toward evacuation of blood from the pleural cavity and restoration of the blood volume. Initially, sufficient blood should be removed to relieve the respiratory distress and mediastinal venous obstruction. Meantime, sufficient blood should be administered to restore the blood volume and content to normal. In an emergency, blood from the pleural cavity may be citrated, filtered and autotransfused if there is no gross contamination, and if the injury is of short

save many limbs which otherwise might have been preserved. Treatment of the ischemic limb takes precedence over treatment of any associated injuries which do not threaten life itself.

TREATMENT OF VASCULAR INJURY

Definitive treatment of the vascular injury depends upon the vessel involved and the nature of the trauma to it, the presence or absence of bleeding and the ease or difficulty with which it is controlled, the presence or absence of ischemia of the limb, and the nature of the associated injury to the limb itself.

Bleeding is apt to persist when a large vessel is lacerated or torn. Arterial injuries tend to be followed by more persistent bleeding than venous injuries. Clean injuries without significant contusion favor continued bleeding. Hemorrhage tends to be persistent when there is a ready route of escape for the blood. Incomplete lacerations of vessels are more prone to continue to bleed than instances of complete division. In contrast, the following factors favor spontaneous cessation of bleeding:

1. Injury to small veins and, to a lesser extent, of small arteries.
2. A large badly contused injury with maceration of tissue favoring blood clotting
3. An injury which provides no ready path of exit for the blood.
4. Severe contusion of the injured vessel itself.
5. Complete division of the vessel rather than partial laceration, permitting retraction and thrombosis of the divided ends.
6. Concomitant injury of an adjacent vein into which the lacerated artery may bleed with formation of an arteriovenous communication.

If bleeding stops spontaneously, any needed definitive treatment can be deferred for a reasonable time, provided that the limb is not ischemic and any existent hematoma is not causing compression of adjacent nerves. When bleeding does not stop spontaneously and when the limb is ischemic, treatment must be carried out without a moment's waste of time.

It is difficult to outline the indications for immediate operative treatment since each case must be assayed as an individual problem. Any contused injury, and this is especially true when foreign bodies are present in the wound, must be treated by prompt and adequate débridement. Unless there are other specific reasons for immediate operative treatment, a small, clean, incised wound or one made by a relatively clean foreign body such as a minute fragment of metal or a small missile, does not require débridement.

When an artery has been injured by such a relatively clean wound and there has been no interruption of continuity of a main arterial stem, no indication for operation exists. If there is evidence of interruption of blood flow through an important artery and the limb shows

holds true for small arteries not essential for the nutrition of the limb The choice between ligation and division, or repair, of main arterial stems rests principally upon the experience of the surgeon and the availability of proper facilities for vascular surgery. Maintenance or restoration of continuity of large main stem arteries is obviously preferable, provided the patient can be gotten rapidly into the hands of a surgeon experienced in such techniques. In any vascular suture it is important that the vessel be adequately mobilized and temporarily occluded with rubber-shod clamps or other instruments which do not damage the arterial wall. The intima must be kept moist and the suture carried out with only the finest, nonabsorbable suture material and needles, preferably swedged-on needles. Five or six zero silk is ideal.

End-to-end suture is facilitated by triangulating or quadrangulating the opposed ends of the divided artery by placing three or four traction sutures spaced equidistantly. The anastomosis is then completed by closure of the intervening segments. The traction sutures permit rotation so that the segment being sutured is uppermost in the wound. It is important to bring the intimal surfaces together without interposition of adventitia The Carrel simple over-and-over suture may be used and locked by ligation to each of the traction sutures. Better still is the employment of everting mattress sutures. Interrupted sutures are preferable to continuous sutures They permit a snug closure which does not leak At the same time they obviate hazard of constricting the lumen by pulling a continuous suture too tightly. Lateral closure of rents in an artery is accomplished by the same suture methods.

If vascular grafts are required, suitable autogenous veins are available and serve well The saphenous vein is the most useful source of such vascular transplants Interposition of the graft is accomplished by suturing the two ends of the graft to the divided ends of the artery, end on, using the same technique as in anastomosis of a divided artery. Vascular repair is fruitless if operation is deferred until fixed thrombosis has occurred in the distal arterial tree When arterial ligation is carried out, it is probably best to leave the concomitant vein undisturbed, provided it is uninjured, since there is no conclusive evidence that ligation of the vein increases the effectiveness of the circulation.

MANAGEMENT OF THE ISCHEMIC LIMB

The limb must be carefully protected from all injury. Even pressure from bedclothes may be sufficient to cause necrosis of the digits if the hand or foot is sufficiently ischemic. Bedclothes should be elevated from the part by a foot board or similar device. The limb should be made dependent so that it is below the level of the heart. Such a position favors maximal blood flow. If edema develops, one should try to strike a nice balance, maintaining the limb sufficiently dependent for

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ing. If the wound is left open, the wound edges are covered with fine mesh gauze and an adequate dressing applied. If the pleural space has not been opened by the injury, débridement should be so carried out as to preserve its integrity.

If the pleura has been penetrated, foreign material loose in the pleural space and devitalized tissues are sought out and carefully removed. Lacerations of the lung should be sutured. Large quantities of warm physiological saline solution are used to lavage the pleural space. Antibiotics are applied intrapleurally, and an airtight closure of the chest wall defect is made, if necessary by the use of pedicled muscle flaps. Drainage is obtained by placing catheters (34F–45F) in the intercostal spaces anteriorly and posterolaterally connecting each catheter with an under water-seal system. Suction is seldom indicated during the first forty eight hours after operation.

Intrathoracic Bleeding. Intrathoracic bleeding must be controlled. Continued bleeding is often from the intercostal or internal mammary vessels, and, if it is not possible to control it by other means, thoracotomy is necessary. Injury to the larger systemic intrathoracic vessels, such as the aorta, is generally rapidly fatal, but patients occasionally survive injury to large pulmonary vessels. Continued severe bleeding from the smaller vessels of the lung is of infrequent occurrence. Careful appraisal of all the problems presented is necessary in making the decision as to whether to do a thoracotomy. Features which aid in the decision regarding thoracotomy are: (a) rapid reaccumulation of blood in the pleural space (removal of as much as 2000 cc. of blood within 24 hours does not afford proof of continuing bleeding but does strongly suggest it); and (b) patients in shock who do not show continued improvement following the administration of what would seem to be adequate amounts of blood. For example, if the blood pressure fails to rise to a relatively normal level (above 100 mg. Hg. systolic) after 1500 to 2000 cc. of blood or shows only a transient rise after such an amount of blood, thoracotomy is in order.

Thoraco-abdominal Injuries. Thoracic injuries without continued bleeding or complicated by other important injuries rarely show persistent shock when the disturbances in cardiorespiratory physiology have been corrected The individual with thoracic injury who shows persistent shock in the absence of serious extrathoracic wounds should be suspected of having continued bleeding or gross contamination of the peritoneal and/or pleural spaces, possibly the result of transdiaphragmatic visceral injury. Blood and bile may be sucked into the chest in right-sided thoraco-abdominal wounds. Prompt operation is required in such patients. Continued bleeding due to injury of the heart is discussed elsewhere.

Intra-abdominal hollow viscus perforation or injury of a solid organ

the central portion of the clot liquefies and the periphery becomes organized with the formation of a pulsating false, or saccular aneurysm.

When such hematomas develop from injuries to arteries relatively unimportant in the nutrition of the limb, or when they arise from injuries to main arterial stems with preservation of blood flow through the lacerated artery, definitive treatment should be deferred and carried out as an elective operation at a later date, after tests for collateral circulation suggest that it is so adequate that the artery could be ligated with relative impunity. As has been mentioned previously, if there is evidence that blood flow through the injured artery has been obstructed and the limb is alarmingly ischemic, operation should not be deferred but should be carried out immediately, with the aim of restoring the continuity of the divided artery, if at all possible. Rapid increase in the size of the hematoma with development of neurologic deficits resulting from compression, or threat of rupture, constitutes an exception in which early operative treatment may be required.

When the concomitant vein as well as the artery is injured, the artery is apt to bleed into the vein with the formation of an arteriovenous fistula. Such cases are most apt to develop in small clean wounds. They are usually not attended by continued bleeding to the exterior. Diffuse hematomas which subsequently develop into saccular aneurysms may be associated with them. Under most circumstances the treatment of arteriovenous fistulas can be deferred and carried out as an elective procedure at some subsequent time when the tests for collateral circulation show it to be adequate.

TESTS FOR COLLATERAL CIRCULATION

The collateral circulation cannot be estimated adequately except by obstructing the artery at the level at which it may require ligation. If examination reveals no pulsation of major arteries distal to the site of injury and no ischemia is present, one can safely assume that the artery is already occluded and that any needed ligation can be carried out safely, *provided injury is not inflicted upon functioning* collateral vessels. In order to evaluate the situation in cases in which blood flow has not been interrupted through the injured artery, the artery must be compressed accurately and completely as near as one can to the site of possible ligation. The most useful test is some modification of the Matas reactive hyperemia test. The limb is elevated and rendered ischemic, either by milking the blood from the hand or foot manually, or by temporary application of an Esmarch bandage. All blood flow into the limb is then obstructed by an Esmarch bandage or a sphygmomanometer cuff distal to the site of injury. This ischemic state should be maintained for five minutes. Several minutes before the tourniquet is released and the limb lowered to the horizontal position, the artery

chemic. If untreated, gangrene or ischemic nerve paralysis may develop, either because thrombosis develops in the obstructed artery or because the spasm persists so long that death of tissue takes place. At times arterial spasm may be released and full blood flow returned by blocking the regional sympathetics, either by the paravertebral injection of an anesthetic agent or by spinal or caudal anesthesia. Unfortunately, not all cases of segmental arterial spasm respond so favorably to blocking of the regional sympathetics, apparently because the muscles of the arterial wall may contract forcibly as a response to injury even in the absence of arterial innervation. When the existence of segmental arterial spasm is discovered at operation, the vessel should be stripped of its gross adventitia, bathed in procaine solution, and it may perhaps be useful to inject procaine into the artery proximal to the site of spasm.

OTHER TRAUMATIC REFLEX DISTURBANCES

Even in the absence of injury to important arteries and veins, trauma to a limb may initiate reflex disturbances. If a peripheral nerve is injured, major causalgia may develop; this is particularly apt to occur after incomplete injuries of nerves. The classical picture is one of excruciating pain, almost always burning in nature though frequently associated with other types of pain, felt in the periphery of the extremity, constant and agonizing. These cases respond dramatically to sympathetic paralysis. If procaine blocks are followed by prolonged relief of pain and subsequent blocks by still longer period of relief, one should be encouraged to continue such treatment. If, on the other hand, relief of pain is limited to the period of sympathetic anesthesia, operative sympathetic denervation should be carried out without delay.

More troublesome are the other reflex disturbances which perhaps are best designated as post-traumatic vasomotor disorders. Following trivial injuries the hand or foot may develop any one of a number of disturbances. There is always present some alteration of vasomotor function. Usually the hand or foot becomes cold, cyanotic and wet. If untreated, this vasospasm may persist or it may rapidly be replaced by hyperemia. Eventually, however, vasospasm returns. The hand or foot is always paretic and the patient may have some objective hypesthesia. Edema out of all proportion to the injury sustained may occur. The patient may complain of a great deal of discomfort, usually made worse by attempts to use the hand actively or to walk upon the foot. Following procaine anesthetization of the regional sympathetics, the vasomotor disturbances disappear and the patient notices increased strength in his hand or foot and diminution in pain. Procaine blocks in these disorders are only adjuvants of treatment, however, not the primary therapeutic measure.

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evidence of esophageal perforation cannot be established, large doses of antibiotics are given and the patient is observed for a few hours. If the patient's condition deteriorates, prompt thoractomy is indicated. The perforation in the esophagus is sutured, the mediastinal pleura is left open and drainage of the pleural space is established through two catheters (34F–45F), one inserted through an anterior interspace, the other posterolaterally. Each catheter is connected with a water-seal system

ACCUMULATION OF AIR IN THE THORAX. The rapid and progressive accumulation of air in the thorax usually indicates injury of one of the large bronchi or intrathoracic portion of the trachea and is an indication for immediate surgery. Simple tension or pressure pneumothorax is considered elsewhere. Failure of the lung to expand is an indication of such an injury. Repair of injury to a large bronchus or trachea may be accomplished by using interrupted sutures to close the laceration and then by reinforcing the suture with a flap of mediastinal pleura. If repair is not feasible, excision of the affected lobe or lung may be necessary. When pulmonary resection is necessary the proximal bronchus is closed with interrupted fine silk suture. If the patient's condition is precarious, proximal mass ligation may be life saving until facilities are available for definitive surgery.

Patients with associated injuries of other organs or parts, for instance the urinary tract, head, or extremities, which may also require early surgery, will usually be given a better change for recovery if the thoracic injuries are treated before other operative procedures are undertaken. When there are associated injuries of the extremities, the patient should not be immobilized in a manner which will interfere with coughing and clearing the tracheobronchial tree of secretions.

CARDIAC INJURIES. The heart may be injured by nonpenetrating, penetrating, or perforating thoracic injuries. Contusion of the heart probably occurs more frequently than is realized and, rarely, rupture of one of the cardiac chambers occurs as the result of heavy blows or crushing force over the precordium. However, the great majority of heart wounds are the result of penetrating or perforating wounds. Penetrating wounds often give rise to cardiac tamponade, in which case there may be little actual blood loss. Perforating wounds of the heart usually result in massive hemorrhage into one of the pleural cavities and occasionally to the outside, but in perforating wounds of one of the ventricles, blood may escape from the heart more rapidly than from the pericardial sac, thus producing the picture of [illegible] tamponade plus severe blood loss. It is important that this [illegible] situation be recognized at once.

Cardiac tamponade is usually the result of wounds which pen[illegible] the chest wall in the area in which the pericardium is not covered b[illegible]

TREATMENT OF BURNS

During the past few years there has been renewed interest in the treatment of thermal injuries. This has caused intensive clinical and laboratory experiments which have helped clarify this subject, and sounder ideas on the management of burn shock and methods of removing the whole thickness slough have been developed. Despite this experimental work there is, to date, no drug or medication alone or in combination which has been proved effective in either preventing or altering the course which a burned patient usually follows.

Thermal injuries produce wounds which vary greatly as to extent, depth and anatomical location. Whenever the burn involves a sufficient area of the body, a definite systemic response is produced which is *termed "burn shock."*

The objectives of care are to cleanse and protect the wound immediately, and, at the same time, to repair the systemic alterations produced by the shock state. A burn produces a contaminated wound, which, initially, is very difficult to assess accurately as to depth or extent. Therefore the wound must be cleansed and protected, and attention directed immediately to the prevention or care of burn shock. As soon as an accurate estimation of the extent and depth of the burn can be made, the surgeon is confronted with the identical problem found in any traumatic wound, namely, to convert the open, contaminated wound into a clean, closed wound as rapidly as is practical for the patient. In burns, closure of the wound often demands skin replacement by grafting.

LOCAL CARE OF THE BURNED WOUND

First Aid. First aid for a burn can be very simple in civilian practice, for all that is required is to protect the wound and transfer the patient immediately to a hospital where facilities are available for complete care. Application of home remedies such as ointments, butter, lard, et cetera, too often leads to delay and unnecessary contamination. Simple protection by the use of the cleanest available material to exclude the air is the most practical type of first aid.

Hospital Care. Immediately upon admission to the hospital the patient should be quickly assessed as to type of burn and, roughly, the extent of burn. Many minor burns, of course, do not demand hospitalization nor will these patients exhibit shock. When the area burned is larger than the "flash burn" area, namely, the exposed hands and face,

Prepared by Harvey S. Allen, M.D., F.A.C.S., Chicago, and sponsored by the American Association for the Surgery of Trauma.

monary in nature, (4) burns of the axilla or perineum, and (5) chronic, infected burns. The routine use of antibiotics carries a definite hazard due either to the bacteria becoming resistant to the drug or to the patient's developing sensitivity to the drug, and it seems that the local application of antibiotics is especially inclined to lead to these complications

It is most difficult, initially, to estimate the extent of the burns accurately, for this takes several hours to become apparent. Extent of burn is usually overestimated and such estimation can be dangerous if this is the basis of any formula for shock treatment. A practical but very crude method of estimating the burn extent can be the "rule of nine": that is 9 per cent for head and neck; 9 per cent for each upper extremity; 18 per cent for each lower extremity; 18 per cent for anterior trunk and 18 per cent for posterior trunk. It must be emphasized, likewise, that the depth of a burn is most difficult to determine immediately, and is usually made in retrospect. It is only five to nine days after injury that the exact depth and extent of the burn can be determined accurately.

Exposure Method. One of the rediscovered methods of local care is that termed "exposure." *This method relies on exposing the burn wound to* the atmosphere. The advocates of this method believe its value lies in the drying of the crust, which reduces the possibility of infection. This method eliminates the necessity of dressings but requires excellent nursing care and a thorough understanding on the part of the patient in order for him to comprehend and to co-operate. The advocates of the open treatment suggest that the dry crust be allowed to remain in place until epithelialization has started from the edges and the crust can be lifted away.

Exposure of a burned area to the air is painful and drugs are therefore necessary to control the pain. This use of drugs may at times confuse the clinical picture of burn shock. Without excellent nursing care the exposure treatment is impractical for burned children, and its use is not possible on an encircling burn of the extremities or the trunk. However, with adequate nursing care, the patient can be turned frequently to aid in the drying process during the first few days. The exposure method cannot be used for a burn complicated by other injuries.

Finally, exposure is of value only during the initial period of treatment. After five to eight days when a whole thickness burn is evident, removal of the slough and a compression dressing over the third degree burn are demanded. Exposure has no place in the treatment of raw open wounds, and therefore when it is apparent that there is a whole-thickness loss of skin in a burn, the exposure method must not be used. Briefly then, unless the burn is superficial, this method is of value only during the first few days or in the early phases of the burn.

monary in nature, (4) burns of the axilla or perineum, and (5) chronic, infected burns. The routine use of antibiotics carries a definite hazard due either to the bacteria becoming resistant to the drug or to the patient's developing sensitivity to the drug, and it seems that the local application of antibiotics is especially inclined to lead to these complications

It is most difficult, initially, to estimate the extent of the burns accurately, for this takes several hours to become apparent. Extent of burn is usually overestimated and such estimation can be dangerous if this is the basis of any formula for shock treatment. A practical but very crude method of estimating the burn extent can be the "rule of nine": that is 9 per cent for head and neck; 9 per cent for each upper extremity; 18 per cent for each lower extremity; 18 per cent for anterior trunk and 18 per cent for posterior trunk. It must be emphasized, likewise, that the depth of a burn is most difficult to determine immediately, and is usually made in retrospect. It is only five to nine days after injury that the exact depth and extent of the burn can be determined accurately.

Exposure Method. One of the rediscovered methods of local care is that termed "exposure." This method relies on exposing the burn wound to the atmosphere. The advocates of this method believe its value lies in the drying of the crust, which reduces the possibility of infection. This method eliminates the necessity of dressings but requires excellent nursing care and a thorough understanding on the part of the patient in order for him to comprehend and to co-operate. The advocates of the open treatment suggest that the dry crust be allowed to remain in place until epithelialization has started from the edges and the crust can be lifted away.

Exposure of a burned area to the air is painful and drugs are therefore necessary to control the pain. This use of drugs may at times confuse the clinical picture of burn shock. Without excellent nursing care the exposure treatment is impractical for burned children, and its use is not possible on an encircling burn of the extremities or the trunk. However, with adequate nursing care, the patient can be turned frequently to aid in the drying process during the first few days. The exposure method cannot be used for a burn complicated by other injuries.

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Wounds of the heart should be operated upon promptly under the following circumstances:

1. When tamponade cannot be relieved by pericardicentesis because of clotting of blood within the pericardial sac;
2. When tamponade, due to failure of the wound to seal off, continues or recurs rapidly; or
3. When bleeding into the chest cavity or to the outside continues.

Otherwise heart wounds should be treated conservatively, at least until the operation (including pericardicentesis) can be performed under satisfactory conditions.

Cardiorrhaphy. If differential pressure anesthesia is available, a transpleural approach through a long incision in the third and fourth intercostal spaces anteriorly is preferable. If additional exposure is necessary, the adjacent cartilages may be divided at the sternum. Where proper facilities are not available for differential pressure anesthesia, the operation may be performed extrapleurally under regional block and local infiltration anesthesia. When the latter method is employed, a curved, left parasternal incision is best, and usually three cartilages and segments of the corresponding ribs (three, four and five) are resected subperiosteally. The internal mammary vessels and the corresponding intercostal arteries are ligated and the prepericardial areolar tissue is incised perpendicularly near the sternal border and dissected to the left, carrying the pleural fold with it. The pericardium is opened widely, the blood is removed by suction, and the wound is located. Bleeding is controlled by pressure over the wound with the index finger of the left hand and a deep traction suture is passed beneath the compressing finger. Slight traction on this suture will largely control bleeding while the approximating sutures are placed and tied. The traction suture is then removed. Cardiorrhaphy is best done with interrupted sutures of medium, 000 or 0000 silk on a slender curved needle. Apical traction sutures should be employed only when the wound is difficult of exposure. The pericardium is closed with a few widely spaced interrupted sutures. In the presence of excessive cardiac irritability the intrapericardial injection of 10 cc. of two per cent procaine is advisable. Drains are not placed within the pericardial sac.

In rare instances patients with wounds perforating the pericardium and heart will survive for considerable periods. Such cases may lead to confusion and delay because of the combination of signs of cardiac tamponade and massive hemothorax. This combination of findings indicates a grave prognosis, but, if conditions permit, thoracotomy and cardiorrhaphy should be undertaken immediately. The transpleural approach through a long intercostal incision can be executed more rapidly and gives a more adequate exposure for repair of the posterior heart wound.

kilograms = cubic centimeters of plasma, plasma expanders, and/or blood needed in the first 24 hours. An equal amount of isotonic saline should be administered, plus 2000 cc. of a solution of glucose in water. For example, fluid requirements in the first 24 hours for a 70-kilogram man suffering a 35 per cent body burn would be as follows:

plasma, plasma substitute and/or blood in cubic centimeters = 70 × 35	= 2,450 cc.
electrolyte solution 0.9% saline	2,450 cc.
5% dextrose in water	2,000 cc.
Total, first 24 hours,	6,900 cc.

This formula cannot be applied rigidly and many believe too much saline is advised.

Theoretically, the fluid requirement for each patient demands, first, sufficient quantity to restore blood volume and red cell mass to normal range; second, to maintain blood volume at normal range; and, third, to allow for renal deviation. A practical method of management which has proved useful, but one which demands constant observation, is as follows: as soon as the patient is admitted, perform a venipuncture with a large-caliber needle. If the burn is extensive, the peripheral veins are collapsed and a "cut down" may be necessary. Get into the vein, get a blood specimen for cross-matching, start intravenous fluids and plasma or plasma substitutes as soon as possible. Have the blood checked initially for the hematocrit level and also for typing. The hematocrit may not be elevated immediately but, in extensive burns, the hematocrit will show rather marked rise a few hours after burning.

At the same time, for a burned patient with either actual or potential burn shock, an indwelling catheter is placed in the bladder so that hourly urine flow may be recorded The initial residual urine specimen is checked by the usual routine urinalysis. The objective of shock treatment is to maintain an average urinary flow of from 25 to 50 cc. per hour for the average adult.

Most burned patients can tolerate oral fluids if these are administered at a definite rate which does not overload the gastrointestinal system. The thirst of the patient must, in the main, be combatted by intravenous therapy, and only limited fluid amounts by mouth are allowed or vomiting will result. An oral intake of 200 cc. per hour for the average adult is adequate and this may be a chilled solution consisting of one teapoon of salt and one-half level teaspoon of bicarbonate of soda to a quart of water. The routine treatment is to get into a vein, to start the plasma, to get into the bladder, permit an oral intake of only 200 cc. of fluid per hour, and to regulate the intravenous rate of fluid so as to obtain urinary output of at least 25 cc. per hour. The patient is constantly observed for his general appearance and if thirst is excessive,

anemia and a marked reduction in the protein level of the blood with a reversal of the albumin-globulin ratio. It is necessary again for the surgeon to anticipate these events. They are likely to occur wherever there has been a genuine shock state demanding therapy. It is at this time, following recovery from shock, when infection may be anticipated.

To combat this phase of a severe burn the weight loss and secondary anemia, it is essential to provide the patient with adequate food, whole blood and vitamins, so that this deterioration does not continue. The patient's general resistance must not be so lowered that the ever-present contamination of the wound develops into a significant infection. The patient should be supplied with a diet which is high in proteins, carbohydrates and fat. These are instituted to meet the need for tissue repair, red cell regeneration, liver protection and the requirements of metabolism. The use of continuous nasogastric drip feedings insuring an intake of 200 to 400 grams of protein, in addition to the usual diet, is valuable. Various formulas are advocated for the administration of high protein diets and they all include the use of some whole protein formula of milk, powdered milk or protein concentrates. Mixtures high in fat provide necessary calories, and thereby allow the administered protein to be spared and used for repair.

Large amounts of polyvitamin preparations are administered daily.

During this phase, until healing has occurred, whole blood transfusions may be required. This is essential to maintain the proteins of the blood at a high, healing level, thus enabling the patient to combat infection, and facilitating the normal healing of the incomplete-thickness burn or grafted full-thickness areas. It is obvious that the best way to prevent the usual sequelae of weight loss and blood alterations is by converting the open wound into a closed wound as early as possible and to stop the continued protein loss from the open wound and to circumvent immediately all possibility of infection.

LATER CARE OF THE BURNED WOUND

After admission of the patient, the wound is immediately covered to minimize chemical, bacterial and mechanical trauma. A quickly, well-applied compression dressing not only prevents pain but also aids in diminishing the amount of outflow of fluid into the burned tissues.

During the time of burn shock the dressing is not disturbed, and the patient should be well stabilized before the burned wound is inspected. During this interval the dressings are inspected daily and re-enforced when necessary.

After five to eight days it is entirely logical to inspect the wound. At this time it should be thoroughly understood that nothing will be gained by complete removal of the entire dressing, but rather the outer, pre-

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EARLY CARE OF INJURIES TO THE ABDOMEN

INTRODUCTION

William F. MacFee, M.D., F.A.C.S., New York

EARLY CARE OF INJURIES TO THE ABDOMEN depend first of all upon early recognition and correct appraisal. When the injury is of the penetrating variety, its probable nature and the structure involved are more readily surmised than when the injury has been produced by a nonpenetrating force. If it is suspected that a penetrating wound involves the peritoneal cavity, it is mandatory to explore the abdomen with the least possible delay.

When the abdomen has been injured by a nonpenetrating force, there is often a question as to whether the injury involves intra-abdominal viscera. A satisfactory answer requires exceptional diagnostic acumen. The significance of important symptoms and signs must be recognized early if the necessary surgical measures are to be taken in time to be effective or, on the other hand, if the patient is to be spared an unnecessary operation.

Abdominal injuries as a rule involve a number of different structures, such as blood vessels, hollow viscera, and solid organs. In a discussion of abdominal trauma it is obviously impossible to include all the possible combinations of injuries

The tentative diagnosis of penetrating wounds of the digestive tube is usually not difficult. The presence of a wound of entry and a wound of exit, if such exists, and a knowledge of the causative agent often provide sufficient evidence for a presumptive diagnosis of such injury. The organs most likely to be involved naturally depend upon the course of the missile, which usually is straight, or upon the thrust of the penetrating instrument. The absence of a wound of exit in the case of bullet wounds, or the lack of factual data concerning the type of weapon in stab or cutting types of wounds, may increase the difficulties of assaying the extent and location of internal injury.

If there is a question as to whether the wounding agent has actually entered the abdominal cavity, this point is better clarified by excising or debriding the wound rather than by attempting to probe it.

If it is certain or even probable that a missile or ihstrument has

Prepared by a special committee of the American Surgical Association composed of the following: William F. MacFee, M.D., F.A.C.S., New York, James M. Mason III, M.D., F.A.C.S., Birmingham, Charles B Puestow, M.D., F.A.C.S., Chicago, John D. Stewart, M.D., F.A.C.S., Buffalo, and Ambrose H. Storck, M.D., F.A.C.S., New Orleans.

drugs and associated remedies are effective in superficial deep burns. However, when the burn slough involves fascia, or deeper structures, these agents are not usually effective and, to produce results, the slough may require "crosshatching" under general anesthesia to allow these agents to penetrate to the undersurface to aid in digesting the collagen fibers. The principal advantage of these agents is that they can be applied easily. However, they are not always effective in accomplishing the desired result, and frequently pain is associated with their administration. Also, there is some additional expense involved.

(c) SURGICAL DÉBRIDEMENT. This method should never be used on the face or neck where there is adequate blood supply, which normally produces rapid sequestration. It is an ideal method for removing the larger sloughs of tissue, but there can be shock if the burned wound is large. After eight to ten days, when it is proved that the burn is whole-thickness in type, the patient is taken to the operating room. There, under general anesthesia, the surrounding areas are gently cleansed and the necrotic tissue is completely removed by sharp dissection. It must be stressed that this is not a "block dissection." If the surgeon takes care to follow the contour and the irregularities of the depth and extent of the burn, he will be following a line of edema in which there is minimal bleeding. It cannot be emphasized too strongly that only unquestionably necrotic tissue is excised. When the resulting open wound is extensive, it is wise simply to cover it with a large previously prepared sterile dressing and apply compression over the wound. No ointment or drug is applied to the wound. The patient is returned to his bed and 48 hours later again taken to the operating room where skin grafting is performed It is wise to have whole blood on hand when one undertakes to care for an extensive wound in this manner.

When the wound is inspected 48 hours after surgical excision, there may be small areas which show that the entire burn slough has not been removed. This is not to be considered a fault but rather that conservatism was used at the time of excision. It is entirely possible to remove these small areas of deeper slough at this time and to proceed with closure of the wound by grafting. It must be mentioned that by following this method the wound does not appear as might be expected when the slough is removed by other methods, for the bed of granulation tissue is not present. However, if the entire thickness of necrotic material has been removed, successful grafting can readily be anticipated. In localized, burns of smaller size where it is possible to control the oozing and hemorrhage adequately, immediate skin closure by grafting can be performed

Delay in removal of the necrotic slough will encourage infection which is of real danger to the patient. If an infection occurs under the necrotic material, the slough will separate but the life of the patient is in

The donor sites may be used again and again, provided a definite, thin, split-thickness skin graft is taken. After all, the surgeon should cover these open burn wounds with the type of graft which has the highest probability of survival, and that is a split-thickness graft. This is not the time to be concerned with the final appearance, but is rather the time to close the wound. The proper time to revise contractures or scarring is at a later date when these complications have developed to their maximum extent.

It is, however, within the province of the surgeon to minimize any unnecessary scarring, particularly at the joints, if he can place the skin dressings transversely across the joints rather than parallel to the limb, for this will diminish the probability of later contractures. However, this too is only of value where the burn is broad enough at the joint level to enable the surgeon to make this decision. Finally, the anatomical site of the whole-thickness burn makes no difference, for every site should be closed rapidly. In other words, just because the burn might involve the face, neck or perineum is no reason to delay closure. Frequently, if the burn is extensive, it is wise to protect the patient with blood transfusions at the time of the grafting operation.

The skin grafts are spread out and applied over the open wound and are held in place by a few sutures, over which a large compression dressing is gently applied. It is the practice to inspect these wounds five to eight days after grafting and subsequent dressings may be performed as the condition of the wound dictates. After grafting, extremity wounds are splinted to prevent unnecessary motion, and this compression dressing and immobilization are continued until the wounds are healed.

If infection occurs, the granulations become pale, fibrous and "piled up." In such a case, the patient's general condition is also poor and is reflected in the appearance of the wound. To prepare such a wound for grafting demands daily aseptic care, moist dressings as soon as the wound permits, and compression dressings. Cultures of these wounds should be taken to determine the exact type of bacteria, so that the patient may be given the proper antibiotic. Before grafting these chronically infected wounds, it may be necessary to excise the granulations down to the firm, yellow base; however, it is surprising how few cases really need this and, further, there is a real danger from blood loss following such a procedure There is the added hazard of hematomas forming under the skin grafts.

Burns in the Extremes of Age. It is important to speak of the variations which occur in the treatment of burns in infants and elderly patients. The infants show a very marked shock state which can vary considerably from hour to hour. The principles of care for shock are identical with those for adults, but the volume of fluid administered must be more carefully observed and the surgeon must be content with

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Nonpenetrating Wounds

Nonpenetrating wounds of the abdominal viscera encountered in civilian practice are commonly due to automobile and other transportation accidents, to industrial accidents, to riding and other activities associated with sports, and to various acts of violence.

The diagnosis of nonpenetrating injuries is far more difficult than that of penetrating injuries and failure to recognize visceral rupture is by no means uncommon. Delay or failure of diagnosis accounts in large measure for the consistently high mortality in this type of abdominal trauma.

Most of the symptoms and signs of intra-abdominal injury associated with nonpenetrating agents are of a general character and may give little precise information. A simple, severe contusion may cause shock, pain, tenderness, rigidity, and most of the symptoms and signs found in the actual bursting of viscera. Ileus occurs frequently after simple abdominal contusion. It becomes obvious, therefore, that the means of distinguishing contusion from actual visceral rupture are limited.

[illegible] hol [illegible] the [illegible] those indications may be added absence of abdominal respiratory movements, and absence of peristaltic activity as determined by silence on auscultation. Roentgenographic demonstration of free gas under the diaphragm and the presence of blood in the vomitus or in the stool are further indications of intestinal injury. A progressive elevation in the leucocyte count and a rising temperature provide confirmatory evidence.

Diagnosis is often complicated by other injuries received at the same time, and the decision as to whether perforation exists is finally based on the total picture rather than upon any one indication.

As a practical approach to the subject it seems best to take up the common injuries to definite important viscera separately, recognizing of course that associated injuries of other structures may be present.

THORACO-ABDOMINAL WOUNDS

James M. Mason III, M.D., F.A.C.S., Birmingham

The term "thoraco-abdominal" is used to designate those wounds in which the pleural and peritoneal cavities and the diaphragm have all been transversed or otherwise injured, and is not applied to separate wounds of the thorax and of the abdomen. Although these wounds are discussed in the section on thoracic injuries, some additional comments are made here.

In many instances, the amount of pulmonary damage is relatively minimal and would not, in itself, warrant a thoracotomy. The necessity

he must very quickly reach the trachea to perform the operation.

The other type of "lung burn" is that in which there is no obvious obstruction but the patient starts with a productive cough and later has almost a continuous frothing from the upper respiratory regions. Tracheotomy is of no real value in these cases and suction is only of temporary benefit. In all such cases the involvement of the respiratory tract is of such intensity and so widespread that the resulting edema is scattered throughout at a level too low to enable the patient to be benefited by a tracheotomy. Prognosis on burns of the respiratory tract should always be guarded. Needless to say, in those burns of lesser degree, it is wise to check the lung fields constantly, both clinically and by x-ray. There are often multiple small areas of atelectasis scattered throughout both lungs. This can be treated best by protecting the patient with antibiotics and aiding him with the use of oxygen, preferably in a tent.

Burns of the hands constitute a very common problem. The principles of care are the same as for burns elsewhere in the body. Initially the burned hand is carefully cleansed, rings removed and the fingers dressed individually. The entire hand is placed on a splint to maintain the position of function* and to enable the surgeon to apply compression to the entire involved part. The hand is inspected after five to eight days and if there is frank whole-thickness involvement of skin, it is advantageous to remove this under general anesthesia and, using a bloodless field obtained by a blood pressure cuff, to apply an immediate skin dressing at this time. The difficulty of securing a satisfactory result in the treatment of this common site for a burn is conducive at times to an attitude of defeatism.

It is granted that one cannot make every burned hand appear perfectly normal However, it must be remembered that, if infection can be avoided, the variation of depth of the burn will determine the outcome of the burned hand. Occasionally the burn is of such depth that fingers are gangrenous and they should be removed at the level of demarcation. Burns on children's hands occur more frequently on the palmar aspect, while burns of adults' hands are more common on the dorsum. However, regardless of anatomical site, rapid removal of whole thickness slough and coverage by skin dressings will often prevent the small joints and tendons from becoming necrotic.

Burns of the perineum present a difficult problem of management, particularly in young children and in infants. These burns, fortunately, are most often of the incomplete-thickness type—the result of sitting in a bucket of boiling water et cetera. The use of a catheter can prevent urinary contamination during the first few days. The entire perineal area may be dressed in the usual manner and the dressing is carried up

*See footnote, page 120.

EARLY RECOGNITION AND MANAGEMENT OF SHOCK

Traumatic shock is a clinical state characterized by varying degrees of peripheral circulatory failure. In most wounds and injuries it is dependent upon a reduction in blood volume plus any other anatomical and physiological alterations produced by the trauma. Properly timed initial surgery of the wound or injury is an essential part of the management of shock. Ill-advised or improperly timed surgical procedures may initiate or exaggerate shock.

The important etiologic factor in traumatic shock is a decrease in the volume of circulating blood. In most instances this reduction in blood volume is brought about by the loss of whole blood. Tremendous loss of whole blood may occur in open fractures of the extremities. As much as two or three liters may be lost in the tissues in a closed fracture of the femur. Multiple fractures involving the spine or pelvis have resulted in death from shock due to blood loss into the tissues. Often there is extensive loss of whole blood in wounds of the chest, abdomen or extremities Determinations have shown losses of from 40 to 75 per cent of the blood volume in severe shock Those in mild shock have usually lost 20 per cent Accurate measurement of blood loss in various surgical procedures has yielded surprisingly high figures. Cognizance of this is important in estimating blood needs for the wounded and injured in whom surgical intervention is an essential part of therapy

Plasma loss, in addition to that lost in whole blood, occurs in certain wounds and injuries Burn shock is due predominantly to loss of blood plasma from the burned area. However, recent observations would indicate that, even in burns, the early need for whole blood is present. Extensive plasma loss also occurs in crush injuries, gas gangrene and other infected wounds with extravasation of plasma into the tissues or from the wound surface In abdominal wounds, and injuries accompanied by gross soiling of the peritoneum with feces or gastrointestinal content, plasma is lost through exudation from the serosal surfaces.

With allowance for the exceptions mentioned above, blood volume studies in patients with traumatic shock have shown depletion of hemoglobin or red cells to exceed that of plasma. This may be explained by a fairly rapid shift of plasma fluid from extravascular areas into the blood stream. A comparable compensatory reserve does not exist for the red cells. This factor further emphasizes the need for whole blood or red cells rather than plasma.

Prepared by Howard E. Snyder, M.D., F.A.C.S., Winfield, Kansas.

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The seriousness of thoraco-abdominal injuries may be considered in regard to the number of intra-abdominal viscera that are damaged. The anatomical position of the viscera allows for classification of the wounds as to the side of the body involved. When the wound is a perforating one, the trajectory of the missile may be projected by lining up the wound of entrance with the wound of exit and the organs involved may be fairly well predicted. When the injury is a penetrating one, the course of the missile cannot be so well visualized. Anteroposterior and lateral x-ray views of the chest and abdomen or stereoscopic views will be of great help in locating the position of retained foreign bodies and often by studying such x-ray films the course of the missile can be traced by flecks of opaque material left in its wake.

When the right diaphragm is traversed the liver is almost always injured. The liver often acts as a barrier preventing damage to other organs. However, when an intraperitoneal organ other than the liver is injured from the right side, it usually means that the liver has been traversed by a missile or transmitted force and serious damage has been inflicted, which is reflected in higher mortality in right-sided lesions.

In left-sided injuries more intra-abdominal organs are apt to be involved and from that viewpoint they may be considered more dangerous than right-sided ones. However, as pointed out above, abdominal visceral injury sustained from the right is usually more serious because of the associated damage to the liver.

Cardiorespiratory Physiology in Thoraco-abdominal Injuries

Although the general concepts of resuscitation of the injured apply equally as well to those with thoraco-abdominal wounds as to those with abdominal wounds, still the former group requires additional attention towards the disturbed or potentially disturbed cardiorespiratory equilibrium. This disturbance will, of course, be found in varying degrees. No routine can be adopted for all cases, but the surgeon should recognize the problems which this altered physiology presents and be ready to apply measures for correcting them.

Difficulties at times arise in the administration of intravenous fluids because of the potential dangers of overloading a circulatory system already embarrassed by direct pulmonary trauma, hemothorax, pneumothorax, or a combination of these. The damage within the peritoneal cavity, hemorrhage, or peritoneal contamination, may in themselves call for more vigorous and more rapid restoration of blood volume than the pulmonary system can tolerate. Often adequate blood volume can be obtained only after an impaired cardiorespiratory imbalance has been improved or corrected. This can at times be corrected preoperatively, but may not be accomplished without the intervention of surgery.

SYMPTOMS AND SIGNS OF SHOCK

The symptoms depend not only upon the degree of reduction in the volume of blood but also upon the number and character of the complicating factors produced by the wound. The picture of uncomplicated shock is that of hemorrhage.

There is no one constant, reliable clinical index of the degree of blood loss. The blood pressure is perhaps the most reliable criterion. With slight or moderate hemorrhage, a compensating vasoconstriction may maintain a normal or near normal blood pressure. With movement of the patient for radiological study or surgery, or with further bleeding, the blood pressure may drop precipitously. In severe hemorrhage, the blood pressure may be so low it cannot be determined in the arm. Frequently, the patient with 0/0 blood pressure on admission to the hospital will show immediate improvement when the foot of the litter is raised and the wounded parts are kept at rest. The pulse pressure *rarely shows any significant decrease until there has been a* significant drop in the systolic blood pressure. The pulse rate is not nearly so reliable as the blood pressure in estimating the degree of blood loss Frequently, those with low blood pressure will show a normal pulse rate. Most, however, show an increase in the pulse rate as the blood pressure falls In severe shock, the individual is usually pale, white or ashen The veins are collapsed. He seems to be suffering no pain but complains of thirst. Apathy develops but consciousness remains until the pressure has been extremely low for a long period of time Sweating is not frequently encountered. There may be some air hunger in the individual with uncomplicated shock. Appraisal of the number and extent of the wounds or injuries is often very helpful in estimating the degree of reduction in blood volume. Observation of response to therapy is of value, for the same reason.

When factors leading to cardiorespiratory embarrassment are present, the symptoms will vary accordingly Hemothorax and pneumothorax may lead to dyspnea or orthopnea and occasionally cyanosis. Inspection, percussion and auscultation will usually establish the diagnosis, but a radiogram of the chest is always helpful. Painful chest wall wounds or multiple rib fractures may limit the respiratory excursions seriously and prohibit effective coughing so that secretions, blood or exudate may accumulate in the tracheobronchial tree. With cardiac tamponade, there is lowered blood pressure with greatly diminished pulse pressure, distant or absent cardiac sounds and distention of the veins of the neck and upper extremities. In laryngeal obstruction, there is pronounced dyspnea, often with laryngeal crowing and retraction of supraclavicular, infraclavicular and intercostal spaces with inspiration. Paradoxical respiration in flail chest is easily recognized

difficulty, leave the litter level. If head or chest injury is present and the blood pressure is normal, elevate head slightly. If a maxillofacial injury with bleeding is present, place patient in the prone position.

2. Control hemorrhage. Venous hemorrhage is best controlled by local pressure. Arterial bleeding is best controlled by ligature or by the application of a hemostat. When hemorrhage can not be controlled otherwise, a tourniquet may be used to control arterial hemorrhage in an extremity if the journey to the hospital is not a long one and can be accomplished quickly. When a tourniquet is applied to control hemorrhage, it should not be loosened or removed until the bleeding vessels have been tied or until blood transfusion has been started so that any further blood loss may be replaced rapidly.

3 Apply dressings of sufficient size and thickness to all wounds to serve until the patient is in the hospital and ready for surgery. Dressings on all chest wounds should be firmly strapped in place to occlude the wound effectively, whether or not the wound is sucking at the time of the dressing.

4. Properly splint fractures or wounded extremities.

5. Insure an adequate airway. Encourage the patient to cough up any blood and mucus in the tracheobronchial tree. Very rarely tracheotomy for laryngeal obstruction must be done before the patient can be transported.

6. If pain is present, give a small dose of morphine sulfate intravenously. This is modified if there is any cranial injury. Intravenous administration is important because, in shock, morphine is absorbed very slowly, if at all, when given subcutaneously or intramuscularly. With a normal blood pressure, after resuscitation from shock, it is absorbed rapidly and, if repeated doses have been given, morphine poisoning may result.

7. Conserve body heat by placing an adequate number of blankets both under and over the casualty. Do not use external heat.

8. If the hospital is distant and the systolic blood pressure is below 80 mm, delay transportation until transfusion of blood or plasma expander* is started Plasma expanders and blood are used only in the smallest amounts necessary to insure the patient's arrival at the hospital alive and without irreparable damage from prolonged shock.

9. Rarely one encounters a tension pneumothorax which must be relieved by the insertion of a needle or catheter into the second interspace anteriorly. The needle or catheter should be attached to a flutter valve made of a condom or a long strip of Penrose tubing. An occa-

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if the left upper abdominal region or the left lower thoracic region is involved. Fracture of the left lower ribs is especially likely to be associated with injury to the spleen.

SYMPTOMS AND SIGNS OF THE SPLEEN INJURY. There is wide variation in the character and severity of symptoms and signs associated with injury to the spleen, depending upon the degree of injury and the amount of intraperitoneal hemorrhage, as well as upon associated injuries of the abdomen or elsewhere. In uncomplicated splenic injuries, clinical evidence is usually sufficient to permit making the diagnosis except in the relatively rare instances in which the injury is slight and in which bleeding has been only subcapsular.

There are usually subjective and objective evidences of shock and hemorrhage, as well as symptoms and signs due to free blood in the peritoneal cavity Abdominal pain, tenderness and rigidity, although usually diffuse, may be limited to the left upper abdominal quadrant and there is often limitation of abdominal respiratory movement. Flank dullness or even flank fullness, especially on the left side, may be detectable. Diffuse abdominal distention is not uncommon, especially in late cases in which there has been much intraperitoneal bleeding and associated ileus. A mass may occasionally be felt in the left upper abdominal quadrant. Bluish discoloration at the umbilicus is occasionally present.

CLINICAL LABORATORY STUDIES. Clinical laboratory studies, including hematocrit and blood volume determinations, are usually more useful as therapeutic guides than as diagnostic aids.

X-RAY STUDIES. Fluoroscopic and radiographic observations may reveal elevation or fixation of the diaphragm, displacement of the gastric bubble or fractures of the lower ribs, and may also demonstrate associated hemothorax or pneumothorax.

DIAGNOSTIC LAPAROTOMY. At times, due either to equivocal evidence of abdominal visceral injury or multiplicity of abdominal visceral injuries, a diagnosis of injury to the spleen cannot be made definitely by any other means than laparotomy.

Treatment of Injuries of the Spleen

SUPPORTIVE THERAPY BEFORE, DURING, AND AFTER OPERATION. The same general principles of supportive therapy which apply for patients who have undergone considerable blood loss and who are suffering from shock, apply in the management of patients with spleen injuries and should be instituted as soon as possible following injury.

The frequent association of thoracic injuries and the danger of respiratory tract infections require that attention be given to maintenance of an adequate airway, to correction of interference with normal respiratory function caused by pneumothorax, hemothorax,

certain that bleeding has been controlled, and a backlog of patients prevents immediate surgery, blood should be given only in sufficient quantity to maintain a systolic blood pressure of 100 mm. until such time as surgery is undertaken. If the patient is not in shock, but the extent of the wounds or injuries indicates significant blood loss, give at least 500 cc. of blood before starting anesthesia.

8. Oxygen therapy should be started promptly in all cases with severe shock, or chest wounds with dyspnea.

9. Relieve pain from chest wall wounds by injection of 5 cc. of one per cent procaine hydrochloride about appropriate intercostal nerves. With relief of pain, the patient will frequently be able to cough up blood and mucus which he has been unable to raise before from his tracheobronchial tree.

10. If pain is present and morphine has not been administered prior to hospital admission, a small dose may be given intravenously. Before anesthesia, atropine or scopolamine should always be administered.

11. Aspirate hemothoraces and pneumothoraces, using a 16-gauge needle attached by tubing to a vacuum bottle containing citrate (a syringe and three-way valve may be used in lieu of the vacuum bottle). Remove all air and blood. If pneumothorax or a large bronchial fistula persists, introduce a catheter through the second interspace anteriorly and connect with a water-seal bottle.

12. Aspirate a hemopericardium, and immediately move the patient to surgery so that emergency thoracotomy can be performed if bleeding into the pericardium continues. All blood from pleural and pericardial sacs should be collected aseptically so that, if suitable, it may be used for autotransfusion.

13. Relieve dilatation of the stomach by passing a nasogastric tube. Vomiting will be induced usually by the passage of the tube, and suction should be applied for drainage after the tube has been passed. Prior to anesthesia, one must be certain that the stomach is empty. If the patient ingested anything within four or five hours before the time of wounding, the passage of a nasogastric tube prior to anesthesia is indicated

14. Surgery is performed at the optimum time. In those cases responding well to resuscitation therapy, it is better to attain a normal blood pressure before moving the patient to the operating table. In those who show no response to the rapid infusion of 1,000 cc. of whole blood, prepare for emergency surgery to start about the time the administration of 1500 cc of blood is completed. Intra-arterial transfusion is most valuable in cases of this type. Transfusion should be continued at the indicated speed throughout surgery. All blood losses incurred by the surgical procedure should be replaced as the losses occur. Enough additional blood should be given during and im-

USE OF ANTIBIOTICS AND ANTISERA IN TREATMENT OF ACUTE INJURIES

THE MODERN ANTIBIOTIC AGENTS AND ANTISERA are used primarily to prevent, control, or cure infection. In acute trauma infection may develop either in inflicted wounds, in operative wounds required for the treatment of the injury, or in one of the body systems such as the respiratory or genitourinary.

For practical purposes it is necessary to consider that all accidental wounds or wounds of violence are contaminated by bacteria, the number being determined by the amount and type of contaminating material. Since infection is largely the result of bacterial growth upon the pablum of devitalized tissue or debris in a wound, the most important step in preventing infection is the prompt institution of surgical treatment consisting of excision of all devitalized tissue, removal of foreign bodies, hemostasis, and application of sterile dressings, incorporating splints if indicated.

Antibiotics and antisera are generally used as therapeutic adjuncts to surgery in the care of the injured and *should not be expected to take the place of prompt and adequate surgical treatment.* Their chief value lies in the attenuation, limitation, or control of infection by bacteria in wounds residual after débridement, or in the localization of infection developing within wounds when surgical treatment is necessarily delayed or is not possible.

Experience shows that these agents must be used properly to obtain their full effect Their improper use may be followed by limited, incomplete, or absent clinical effect.

As a result of the numerous advances in the field of chemotherapy during the past ten years, the various antibiotic agents have assumed greater, and the antisera lesser, importance in the control of infections.

This chapter will review the various agents which are available, the factors which define their effectiveness and limitations, and the indications, dosage, methods of administration, and limitations of their clinical use

I. ANTIBIOTIC AGENTS

A. General Considerations

Contrary to the current assumption of many surgeons that there is no longer any problem in the prevention or control of infections because of the wide selection of antibiotics which are available, many of the old problems persist and new ones have arisen with the introduc-

Prepared by William A. Altemeier, M.D., F.A.C.S., Cincinnati, and Roger Sherman, M.D., Cincinnati.

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if the peritoneal cavity is found filled with blood at operation the spleen should be among the viscera examined first. If injury is discovered during the rapid preliminary direct examination, splenectomy should be done as soon as possible, unless violent bleeding from some other site demands prior attention. The introduction of gauze or other material into or around an injured spleen for the purpose of temporarily controlling hemorrhage is, almost without exception, an unwarranted and futile procedure.

The impossibility of satisfactorily suturing even a minor wound of the spleen is so well known that there is little justification for even trying this method of treatment in any type of spleen injury. The availability of hemostatic agents, such as oxidized cellulose and gelatin foam, does not alter the need for splenectomy.

Rarely, there may be an injury of a splenic vein without injury of the spleen itself. Under such circumstances, the injured vein may be ligated, without removing the spleen.

The practice of ligating all blood vessels in the pedicle of the spleen without removing the spleen is not to be recommended.

The practice of ligating the splenic artery before ligating the splenic veins, commonly advocated and employed in connection with the elective removal of large diseased spleens, is of little or no value when removing an injured spleen

The administration of spleen constricting drugs immediately before ligating the splenic pedicle vessels, as a means of squeezing out blood from the spleen into the general circulation, has no application in the treatment of spleen injuries.

Repair of a wound of the diaphragm associated with injury of the spleen should be done for both immediate correction of disturbed respiratory function and for prevention of subsequent herniation of abdominal viscera into the thoracic cavity. This may require extension of the abdominal incision upward into the chest wall, as stated previously

If there is contamination of the peritoneum due to perforation of gastrointestinal viscera, drainage of the space from which the spleen has been removed, using rubber tissue drains brought out subcostally through a stab wound on the left side in the midaxillary line, is usually advisable as a possible means of preventing the development of a left-sided subdiaphragmatic abscess. Such drains also afford exit for blood not removed at the time of operation.

Postoperative Treatment. Postoperative treatment following splenectomy is the same as for other major abdominal operations associated with blood loss. From the standpoint of the splenic injury alone, there is no need for administration of antibiotic agents, but this type of therapy is often advisable because of accompanying injuries to other

prolonged infections, whenever possible. Although not infallil. the antibiotic-impregnated disc method gives valuable inf tion and is sufficiently simple for use in any laboratory employ a technician trained in bacteriology.

Many strains of bacteria in our environment are gr acquiring resistance to the antibiotics. Only 48.5 per cent of strains of hemolytic *Staphylococcus aureus* were found to be sensi to less than 10 units of penicillin per cubic centimeter in our l oratory in 1951.

4. Adequate Dosage. The question of dosage is still in a st flux. The evidence indicates, however, that the dose of the biotic agent should be sufficiently large to produce antib concentrations in the blood and intercellular fluids, and that duration of therapy should be sufficiently long to permit natural defensive mechanisms of the body to dispose of inhibited but often still virulent bacteria.

   The majority of agents exert only a bacteriostatic effect, is greatest on actively growing and reproducing bacteria. Fail to continue treatment sufficiently long to permit elim the bacteria by the body's defenses may result in the r appearance or an exacerbation of an infection.

   In the case of some of the antibiotics, particularly p the evidence suggests that progressively large doses have *increasingly greater antibacterial effect*. An example of this is *in vivo* effect of progressive doses of penicillin in ex gas gangrene produced by highly virulent *Cl. welchii*.

5. Early Treatment. Antibiotic therapy should be started as as possible after injury. Its use may keep any infection localized, attenuated, or dormant. It must be remembered chemotherapy may mask developing infection either within wound or elsewhere in the body to the point that its diagnosis localization become very difficult. In established infections, antibiotic therapy gives a better chance of producing rapid prompt control of the invasiveness of the process with taneous resolution, or destruction of a minimal amount of tiss Late treatment usually results in a more limited and dela effect, and complications are more numerous, including lc necrosis, abscess formation, or systemic invasion. Failure recognize metastatic complications usually produces an complete chemotherapeutic response and prolonged morb or death. If the temperature and other general signs of infect do not begin to recede within 72 hours after the start of ch therapy, the co-existence of a neighboring abscess or one or m metastatic infections is suggested.

remembered that the full therapeutic effect of the antibacteriai agent will not be obtained if they are not corrected.

B. Prophylactic Chemotherapy in Acute Trauma

Prophylactic antibiotic therapy should be started promptly in -ll patients with major open soft tissue wounds or open fractures, and co tinued for at least five days, unless special contraindications are present. The selection of the agent depends upon the location and nature the wound and the probable contaminating bacteria. Under di conditions, in which there are many wounded patients, the choice the antibacterial agent may be influenced by the supplies or per available. The oral route of administration and the use of pro' intervals between doses, when possible, are useful in minimizing demand on professional personnel and equipment in disasters. ever, in normal periods, this is not necessary and may not be advi: Initial prophylactic chemotherapy may consist of:

1. Chloromycetin, terramycin, or aureomycin, 500 mg. every 4 to 6 hours orally, for the moderately injured who are able to medication by mouth
2. The parenteral administration of penicillin is recommended those unable to take oral medication, and for all with seriou injuries who are not sensitive to this antibiotic.
   a. Crystalline penicillin G, 50,000 to 100,000 units, every hours intramuscularly
   b. Procaine penicillin G, 300,000 units, fortified with cry lli penicillin G, 100,000 units, preferably in aqueous suspensio may be given intramuscularly every 8 or 12 hours for hours, then every 24 hours.
3. Under disaster conditions, chloromycetin, terramycin, or aureo mycin may be given orally in doses of 750 mg. every 12 hours, procaine penicillin G and crystalline penicillin G in oil, intr muscularly, every 24 hours.
4. In patients with wounds exhibiting extensive tissue necrosis such as severe lacerations, crushing injuries of muscle, compound frac tures, and major arterial lacerations, aqueous penicillin G, 200,000 units, intramuscularly every 4 hours, or 500,000 units every 8 hours.
5. In patients with wounds contaminated by fecal bacteria, such as penetrating wounds of the abdomen, lacerations of the perineum or buttocks, or wounds of the retroperitoneal tissues, the follow therapy is recommended
   a. Aqueous crystalline penicillin G, 100,000 to 200,000 units every 2 hours intramuscularly, and streptomycin, 0.5 gm. intramuscularly every 8 hours. Streptomycin is usually dis-

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the great variation in extent and character of liver wounds. Wounds caused by low velocity sharp objects, such as knives and bayonets, cause relatively little damage to liver tissue beyond the immediate area of the wound, whereas high velocity bullets and jagged shell fragments, as well as blunt forces, often cause damage far beyond the grossly apparent injury.

Wounds of the liver are of the following varieties: (1) contused wounds, with or without subcapsular hematomas; (2) guttered or furrowed surface wounds; (3) lacerated wounds, either linear or stellate; (4) penetrating and perforating wounds, with or without surrounding contusion; (5) macerated wounds; and (6) fragmented wounds.

From the standpoint of management and prognosis, hepatic injuries may be classified according to the degree of associated hemorrhage and shock, the severity of injuries to other parts of the body, and the amount of peritoneal contamination, as well as according to the extent of injury to liver tissue and major bile radicles.

Diagnosis of Injuries of the Liver. The possibility of injury to the liver must be suspected whenever there has been either a penetrating or a blunt injury to the lower chest or the upper abdomen, whenever there has been a fall or jump from a considerable height, and whenever the chest or abdomen has been subjected to either air or water blast.

Determination of the existence of injury to the liver by missiles can usually be accomplished by a careful study of the location and character of the wounds of entrance and exit, or by consideration of the wound of entrance in relation to the position of a retained missile as demonstrated by x-ray examination. In the instance of bullet wounds, a careful study of the wound of entrance in respect to the extent and distribution of skin contusion, and the extent and direction of subcutaneous undermining, will usually furnish helpful information concerning the course of the missile.

Symptoms of Injury to the Liver. The symptoms associated with liver injury may be so slight that the diagnosis is difficult. On the other hand, symptoms and signs may be so definite that its existence is quite apparent. The co-existence of injuries to other abdominal viscera increases the difficulty of determining the existence of, or the extent of, liver injury.

The location and degree of pain associated with hepatic injury are extremely variable, being related not only to the amount of bleeding from the liver and the amount of spillage of bile into the peritoneal cavity, but to the presence or absence of rib fractures and peritoneal irritation due to perforation of other abdominal viscera. Pain [illegible] be limited to the right upper quadrant of the abdomen, but it is [illegible] uncommonly diffuse on the right side or over the entire [illegible]

d. In established clostridial myositis or true gas gangrene, the choice of effective antibiotics is:

(1) Aureomycin, terramycin or chloromycetin in doses of 500 mg. intravenously every 8 to 12 hours, or

(2) Crystalline penicillin G, 1,000,000 units, intramuscularly every 3 hours.

e. Serious *Pseudomonas* (*pyocyaneus*) infections may be treated with the following antibiotics:

(1) Polymyxin B, 2.5 mg. per kilo of body weight per day, giv in three or four divided doses every 8 or 6 hours for 5 to days under close supervision. One per cent procaine as a dilu ent minimizes pain at site of injection. A daily dose of 2(mg. should not be exceeded. Patients treated with polymy xin should be observed closely for signs of renal or neurologi cal toxicity;

(2) Chloromycetin or terramycin is less effective but may b used successfully in about one fourth of the cases.

II. ANTISERA

The only antisera of clinical importance which are used currentl for the prevention or control of infections in patients with wounds tetanus antitoxin and pentavalent gas gangrene antitoxin. A containing antitoxins for the toxins of rattlesnakes, copperhead, a cottonmouth moccasin snakes, may be used in the treatment of from these snakes, but their use does not come within the scope of thi chapter

A. Tetanus

1. Prophylaxis. Tetanus can be prevented by the use of much more effectively than it can be treated after the disease established. Therefore, every effort should be made to prev this dreaded complication of wounds. In fact, general immu tion of all civilians against tetanus by three injections of 0.5 1.0 cc. of tetanus toxoid in an effort to stamp out this disease h been urged.

a. Tetanus antitoxin, 1,500 to 3,000 units hypodermically, a negative skin test, should be given as soon after injury possible to those who have not been previously immuni with tetanus toxoid. A dose of 1,500 units may be used f minor injuries, but a dose of 3,000 units is recommended more extensive soft tissue wounds, open fractures, and injuri caused by blank cartridges and firecrackers. A dose of 3,0 units is suggested when prophylaxis has been delayed for to 48 hours, and a larger dose of 10,000 units when the

sufficient drainage when indicated. There is considerable evidence that the prophylactic administration of gas gangrene antitoxin is of little practical value in the prevention of clinical gas gangrene. Many surgeons, however, use the combined tetanus and gas gangrene antitoxin containing 1,500 units of tetanus, 2,000 units *Cl. welchii*, and 2,000 units of *vibrion septique* antitoxins. If given, it should be injected subcutaneously as soon after injury as possible. When treatment has been delayed for 24 hours or more, its injection should be intramuscular. When available, trivalent or pentavalent gas gangrene antitoxin should be used instead of the bivalent.

2. THERAPY OF ESTABLISHED GAS GANGRENE. There is considerable confusion regarding the value of serotherapy in the treatment of established gas gangrene. However, the evidence suggests that the use of antitoxin, in conjunction with adequate surgery, aids in the control of associated toxemia. This is of particular value in the first 36 to 48 hours after the start of antibiotic therapy until the full effect of the latter is possible. Until more conclusive evidence is produced to contraindicate its use, the following recommendations are made:
   a. The earlier the antitoxin is started, the greater will be its effect. Early diagnosis is of the greatest importance, permitting prompt surgical treatment, use of antibiotics, and administration of antitoxin;
   b. Pentavalent preparations should be used, if available, containing 10,000 units of *Cl. welchii*, 10,000 units of *vibrion septique*, 1,500 units of *Cl. oedematiens*, 1,500 units of *Cl. sordellii*, and 3,000 units of *Cl. histolyticum* antitoxins per vial;
   c. Before injecting the antitoxin, preliminary skin testing of the patient for sensitivity to horse serum is done;
   d If negative, an initial dose of two to four vials of pentavalent gas gangrene antitoxin is given intravenously promptly. The dosage or number of vials used is decided upon after a consideration of the duration, extent, and the rapid course of the infection, as well as the apparent degree of intoxication;
   e. If the toxemia is not significantly altered within 4 to 6 hours, the initial dose of antitoxin may be repeated,
   f. Thereafter, a daily injection of one vial of pentavalent gas gangrene antitoxin may be given until the infection has been brought under control

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   f. Thereafter, a daily injection of one vial of pentavalent gas gangrene antitoxin may be given until the infection has been brought under control

Hematocrit and blood volume determination are often of value in determining blood transfusion requirements.

Bile in the urine does not appear until several days have elapsed following injury, even after extravasation of large amounts of bile into the peritoneal cavity.

Roentgenologic examination following abdominal injuries is of particular value in the instance of retained missiles. Roentgenologic examination is also of value in demonstrating the existence and extent of thoracic injury which is so frequently associated. Fluoroscopic and radiographic examination may also be employed to demonstrate immobility or elevation of the diaphragm. Following operations roentgenologic examinations are of value in demonstrating the presence of the not uncommon complicating subphrenic and liver abscesses.

Peritoneal aspiration to determine the presence or absence of blood in the peritoneum is a valuable means of diagnosis of abdominal visceral injury. Introduction of a Potter needle through the lateral abdominal wall is a safe and very dependable measure.

When multivisceral abdominal injuries exist, it is often impossible to determine whether or not there has been injury to the liver. Under such circumstances definite determination of the existence or extent of liver injury must await exploration of the abdomen.

Preoperative Preparation

The principles of preoperative preparation for patients with injuries of the liver are quite similar to those which apply to all patients with abdominal visceral injuries. The blood loss usually associated with these injuries often demands even more blood replacement than is required by patients with other abdominal injuries. Antibiotic therapy should be instituted as soon as possible following injury both because of the liver damage itself and because of the frequent co-existence of gastrointestinal perforations.

Operative Treatment

The incision may vary somewhat, depending on the suspected location of the injury In general, vertical right rectus or right paramedian incisions are preferable since they permit the extensions which are so often necessary to secure satisfactory access to other parts of the abdomen. Combined intra-abdominal and intrathoracic exposure also can be conveniently provided by upward extension of vertical abdominal incisions Vertical abdominal incisions still further offer the advantage of permitting exteriorization of the colon in a most satisfactory manner if that should be necessary. For the exposure of the dome of the liver, a transthoracic-transdiaphragmatic approach furnishes the best exposure. In some instances it is advantageous to extend the

recognized as the most desirable agent for use in the seriously injured that its merit is also evident for patients who are in less precarious condition. It has been used too little.

Ether is highly inflammable and explosive. In hot climates keep ether cans on ice or in wet bags exposed to a breeze if no ice is available, just before use.

Ether anesthesia is generally best administered through an endotracheal tube. Size 32 F. is satisfactory in most adult patients. Sizes larger than 34 F. are not necessary. A soft wire (copper) introducer will greatly facilitate the insertion of an endotracheal tube.

LOCAL ANESTHESIA

Local anesthesia is accomplished chiefly with procaine hydrochloride (*tetracaine or cocaine for topical anesthesia*) for neurosurgical, for some maxillofacial and for minor surgical procedures. In great disasters when many casualties are awaiting treatment, regional block procedures are of little value, chiefly because of the skill and time that they require and the frequent multiplicity of wounds. Chief exceptions here are paravertebral or intercostal blocks for controlling thoracic pain, and sympathetic blocks when the circulation of an extremity is impaired.

Epinephrine in 1:200,000 dilution will greatly prolong (triple or quadruple) the action of local anesthetic agents. Use of 0.5 cc. of a 1:1,000 solution of epinephrine to 100 cc. of one per cent procaine hydrochloride. However, epinephrine or other vasoconstrictor agent is not to be used with local anesthetic agents in surgery of the fingers, toes, ears, nose, penis or scrotum. Sloughs may be caused if this is done. Epinephrine is not to be added to local anesthetics if their action is to be supplemented with cyclopropane, chloroform or ethyl chloride.

Sensitive persons or patients who have received an overdose of a local anesthetic agent will often have convulsions Specific treatment is afforded by soluble barbiturates, for example, pentobarbital sodium or thiopental (pentothal) sodium Usually two to four grains (120 to 240 mg.) will be sufficient. The intravenous route of administration is used.

Reasonable doses of procaine hydrochloride will not exceed either 200 cc. of 0 5 per cent, 100 cc. of 1 0 per cent, or 40 cc. of 2.0 per cent solutions. These maximum total doses should not be adminis[illegible]n less than an hour to healthy adults in good con[illegible] agents will be used with gre[illegible] liver disease They wil[illegible]aving a history of sensitivity to them. Inqu[illegible]ays to be made concerning this.

SPINAL ANESTHESIA

Spinal anesthesia is never acceptable for persons recently and seriously injured. Such tolerate it poorly.

certain at this time. Of considerably more importance is the use of atropine. Its purpose is to minimize undesirable vagus reflexes. Atropine sulphate 1/100 grain (0.6 mg.) should be given subcutaneously about one hour preceding anesthesia, with half the dose (1/200 grain, 0.3 mg.) given intravenously just before anesthesia is started. During periods of disaster, in times of heavy admission of patients, there will not be time for the above and it will be satisfactory to give atropine 1/100 grain (0.6 mg.) intravenously 10 or 15 minutes preceding anesthesia. (In the presence of severe tachycardia use of atropine is avoided.) When troublesome laryngeal spasm occurs during thiopental anesthesia, administer atropine 1/100 grain (0.6 mg.) intravenously as soon as possible, even though the same dose was administered in preanesthetic medication shortly before.

CLINICAL CHOICE OF THIOPENTAL (PENTOTHAL®) SODIUM. It is certain that thiopental is of great value. Equally certain it is that the choice of thiopental is contraindicated in the seriously injured. Its use is unwise in the presence of certain injuries.

1. When the patient is suffering from morphine overdosage.
2. When shock is present, or when shock is anticipated. The following wounds and conditions are likely to be associated with shock: penetrating wounds of the chest or of the abdomen, open fractures of the long bones, and severe hemorrhage even when it comes from otherwise trivial wounds. Thiopental (pentothal®) sodium should never be used in the above conditions; ether is far safer, when general anesthesia must be used.
3. When incision of a cervical abscess is to be undertaken, the use of thiopental is unwise. Deaths have occurred in such circumstances. Apparently, inflammation in the region of the carotid bodies and sinuses causes sensitization of reflexes arising there. These probably account for the notorious incidence of sudden death during such operations. Since thiopental (pentothal®) sodium, and other barbiturates are not especially effective in depressing these reflexes, thiopental should be avoided in most cases of this kind. Rarely, as in some cases where open fractures of the face may also be present, thiopental may be the reasonable choice for handling cervical abscesses. In such cases the following precautions should be observed: use heavy atropinization in the preanesthetic medication; do not begin surgical intervention in patients with irritable carotid sinus until at least 10 minutes after induction of thiopental anesthesia; avoid pressure on the carotids; if feasible, block them with local anesthesia.

In another group of patients the use of thiopental (pentothal®) sodium may at times be debatable but is usually unwise.

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compression afforded by the abdominal and lower chest walls before the operative incision was made, or caused by removal or dislodgment of blood clots incident to exploration

In most instances, it is advisable to remove even those blood clots directly in the wound which, although temporarily serving a hemostatic purpose, are likely to become detached subsequently. It is usually better to assure more effectively against possible recurrence of bleeding by suturing the wound or introducing hemostatic agents, such as gelatin foam or oxidized cellulose held in place by means of sutures, than to depend on blood clots alone for hemostasis. When hemostatic agents are employed, they should be used in the smallest possible quantity, since their use in large amounts may contribute to the development of a liver abscess

Many methods, some quite ingenious, have been advocated for the control of bleeding from the liver. Hot moist gauze packs, as well as dry gauze packs, have been extensively employed as an expedient means of arresting bleeding from the liver. The injury to tissue caused by excessively hot moist packs makes their use undesirable. The frequent occurrence of active bleeding at the time of removal of gauze packs left in place at the completion of operation, and the high incidence of abscesses of the liver when gauze packs are so employed, have furnished convincing evidence that this is not a good practice. Under no circumstances should iodoform gauze packs be used, because of the danger of iodoform poisoning.

Violent bleeding from the liver may be arrested temporarily by digital compression of the hepatic artery and the portal vein by passing the index finger through the foramen of Winslow and making counterpressure with the thumb This may be a lifesaving procedure.

The use of actual cautery for the control of liver bleeding is to be avoided.

Removal of Foreign Bodies from the Liver. The presence of single or multiple missiles superficially or deep in the liver substance presents a serious problem Readily accessible foreign bodies which can be lifted out easily without considerable tearing should be removed. Multiple small missiles which may have been visualized by x-ray examination but which cannot be easily seen or readily felt, and which cannot be removed without inflicting considerable additional damage, should be left in place.

Removal of Loose Fragments of Liver, Blood and Foreign Bodies from Peritoneal Cavity. Fragments of liver tissue lying free in the abdominal cavity or portions of the liver which are attached by inadequate pedicles should be removed. Under certain circumstances, contused portions of the liver, particularly portions of the free edge, are best excised. Such excision is likely to be associated with

APPENDIX

IMMUNIZATION AS PROPHYLAXIS FOR TETANUS AND GAS GANGRENE

THE FOLLOWING REPORT was made to the American Association for the Surgery of Trauma by a specially appointed committee. The opinions expressed by the committee, and accepted and approved by the association, represent the best of present current thought on this important phase of wound care. Some recent work on tetanus immunization would seem to show that the levels of serum tetanus antitoxin may remain significant for periods of time even longer than is indicated in the report. This fact, however, simply serves to emphasize the plea of the committee for wider application of tetanus immunization, particularly among those groups of individuals especially liable to injury and exposure.

The committee made the following recommendations:

To establish passive immunization with tetanus antitoxin, for wounds seen within 24 hours after injury, the usual dose of antitoxin shall be 1,500 units Under the circumstances of co-existing diabetes mellitus, arteriosclerotic peripheral vascular disease, a large wound, or known gross contamination, the prophylactic dose of antitoxin shall be 3,000 units

For wounds seen later than 24 hours after injury, the indicated dosage of antitoxin should be doubled for each day of elapsed time up to a total of 10,000 units.

For wounds not susceptible to adequate surgical débridement, containing residual devitalized tissue or remaining unhealed, there is an obligation to prolong the period of protection with antitoxin. The preferred procedure is to repeat the administration of 1,500 units of antitoxin every seven days until the wound is clean or healed. An alternative acceptable method is to administer a larger dose (up to 100,000 units) initially, with the expectation that the larger dose will provide a longer period (up to three weeks) of passive protection.

The use of tetanus antitoxin should always be preceded by appropriate and meticulously performed tests for sensitivity to horse protein. The tetanus antitoxin must be diluted 1:10 in saline solution for intracutaneous or ophthalmic testing. Only a minute amount of the

The Committee for the Study of Immunization as Prophylaxis for Tetanus and Gas Gangrene was composed of the following: Champ Lyons, M.D., F.A.C.S., Birmingham, Chairman, William A. Altemeier, M.D., F.A.C.S., Cincinnati, Oscar P. Hampton, M.D., F.A.C.S., St. Louis, and Howard E. Snyder, M.D., F.A.C.S., Winfield, Kansas. Their report appeared first in the American Journal of Surgery, March, 1954, pages 482–483

The sensitizing effect of the prophylactic serum renders subsequent antitoxin therapy hazardous and uncertain. In individuals not previously immunized with toxoid but now receiving tetanus antitoxin, active immunization with toxoid should be started concomitantly. Toxoid should be one milliliter in quantity, *given in a separate syringe* and *at a separate site*.

When the patient has been immunized by previous administration of toxoid, the coincident use of toxoid and antitoxin may be considered whenever (1) a massively contaminated wound and delayed surgical care create the hazard of onset of tetanus prior to the lapse of a further four to five days required for response to toxoid; or (2) the lapse of more than four years from the time of the last booster dose produces a situation wherein a small but definite group of previously immunized patients require six or more days for response to toxoid. These indications are controversial, but the committee felt they could be recommended.

Prophylactic antitoxin is ineffective and is not recommended in the prophylaxis of gas gangrene. The most reliable prophylaxis of gas gangrene is early and adequate wound surgery (débridement), with the wound being left open. Several days later, when the wound is clean, it may be closed by delayed suture.

Gas gangrene toxoids show experimental promise but await clinical evaluation.

With regard to certain over-all problems, initial immunization with tetanus toxoid for mass prophylaxis is an essential in anticipation of catastrophe. Specific identification of the immunized individual is a part of this recommendation.

Commercial manufacturers should be requested to resume the production of bovine tetanus antitoxin.

There should be wider adoption for civilian injuries of the principles of débridement, with the wound being left open initially as the most effective prophylaxis for all anaerobic wound infections.

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